04.09-07/01/95-00599

FINAL

DECISION DOCUMENT

CAMP ALLEN LANDFILL
NAVAL BASE, NORFOLK, VIRGINIA

CONTRACT TASK ORDER 0084

JULY 17, 1995

Prepared For:

DEPARTMENT OF THE NAVY
ATLANTIC DIVISION
NAVAL FACILITIES
ENGINEERING COMMAND
Norfolk, Virginia

Under:

LANTDIV CLEAN Program
Contract N62470-89-D-4814

Prepared by:

BAKER ENVIRONMENTAL, INC.
Coraopolis, Pennsylvania

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ACRONYMS AND ABBREVIATIONS

ARARs	applicable or relevant and appropriate requirements
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
DoN	Department of the Navy
DOT	Department of Transportation
DPVE	dual phase vacuum extraction
EE/CA	Engineering Evaluation/Cost Analysis
FS	Feasibility Study
gpm	gallons per minute
HI	Hazard Index
ICR	incremental cancer risks
IRP	Installation Restoration Program
MCLs	maximum contaminant levels
NCP	National Contingency Plan
NPL	National Priorities List
O&M	operation and maintenance
PEM	Palustrine Emergent Wetland
PRAP	Proposed Remedial Action Plan
PSS	Palustrine Scrub Shrub
RA	Risk Assessment
RCRA	Resource Conservation and Recovery Act
RD/RA	Remedial Design/Remedial Action
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
SARA	Superfund Amendments and Reauthorization Act
SVOCs	semivolatile organic compounds
TBC	to be considered
USEPA	United States Environmental Protection Agency
USMC	United States Marine Corps
VADEQ	Virginia Department of Environmental Quality
VOCs	volatile organic compounds
VR	Virginia Regulations

DECLARATION

Site Name and Location

Camp Allen Landfill
Naval Base Norfolk
Norfolk, Virginia

Statement of Basis and Purposes

This Decision Document presents the selected remedial actions for the Camp Allen Landfill Site at Naval Base Norfolk in Norfolk, Virginia. The selected remedial actions were chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA), and, to the extent practicable, the National Contingency Plan (NCP). This Decision Document is based on the Administrative Record for the site.

The Department of the Navy (DoN) has obtained concurrence from the Commonwealth of Virginia and the United States Environmental Protection Agency (USEPA) Region III on the selected remedies.

Assessment of the Site

Actual or threatened releases of hazardous substances from this site (consisting of Areas A and B), if not addressed by implementing the response actions selected in this Decision Document, may present a current or potential threat to public health, welfare, or the environment.

Description of the Selected Remedy

The proposed response actions (or preferred alternatives) identified herein address all contaminated media of concern at the site and comprise the overall cleanup strategy for the site. Contaminated media addressed by the preferred alternatives include contaminated soil, surface water/sediment, and groundwater in Areas A and B. Areas A and B of the Camp Allen Landfill Site are described in Section 1.0 and are illustrated in Figure 1-1.

The principal threat posed by conditions at the Camp Allen Landfill Site is that contaminated soil in the Area A Landfill provides a potential source of contamination, which threatens the underlying aquifers. Although groundwater at the site currently is not used for any purpose, contaminated groundwater at the site could pose a human health risk if utilized as a drinking water source under a potential future residential use scenario. The response actions for this site address the principal threat posed by the site via in situ treatment of Area A soils, extraction and treatment of groundwater in Areas A and B, institutional controls, and monitoring. A removal action has been successfully implemented for Area B soil/waste, which has eliminated the primary source of groundwater contamination in this area. The major components of the preferred alternatives for the various media are briefly described below. For a more detailed description and analysis of remedial alternatives, the reader is referred to Sections 7.0 and 8.0 of this document, and to the Camp Allen Landfill Site Final Feasibility Study (Baker, November 1994).

Area A Soil

- In situ treatment of soil and shallow groundwater in Area A1 by dual phase vacuum extraction (DPVE)
    - DPVE system is able to extract both soil and shallow groundwater (water table aquifer) contamination with a single system
    - Groundwater extracted by the DPVE system would be pumped to proposed on-site water treatment plant
- Institutional Controls (maintenance of fence and grass-cover and deed restrictions) for Areas A1 and A2

Area B Soil

- Institutional controls (fence maintenance and deed restrictions)

Areas A and B Surface Water/Sediment

- Institutional controls to restrict future land use
- Monitoring to track trends in contamination levels in these media
- Additional sampling/analysis of surface water/sediment to determine the full extent of ecological impacts to the area surrounding the Camp Allen Landfill

Area A Groundwater

- Protection of the Yorktown Aquifer for beneficial use through extraction and treatment (Area A1)
- Protection of the water table aquifer for beneficial use through extraction and treatment (Area A2)
  - Groundwater extracted through pumping wells would be pumped to an on-site water treatment system
- Groundwater monitoring (Areas A1 and A2)
- Institutional controls (Area A1 and A2)

Area B Groundwater

- Protection of both the water table aquifer and the Yorktown Aquifer for beneficial use through extraction and treatment

- Extracted groundwater from both aquifers would be pumped to an on-site water treatment system

- Groundwater monitoring

- Institutional controls

This combination of response actions is expected to significantly reduce potential human health and environmental risks associated with the site by providing effective source control at the site and substantially reducing the potential for migration of contamination.

Statutory Determinations

This remedial action is protective of human health and the environment, complies with Federal and State requirements that are legally applicable or relevant and appropriate to the remedial action, and is cost-effective. This remedial action utilizes permanent solutions and alternative treatment technologies to the maximum extent practicable, and satisfies the statutory preference for remedies that employ treatment that reduces toxicity, mobility, or volume as a principal element. Because this remedy will result in hazardous substances remaining on site (in the Area A Landfill) above health-based levels, a review will be conducted within five years after commencement of the remedial action to ensure that the remedy continues to provide adequate protection of human health and the environment.

Imoses ______________________ 14 August 95

Signature (Commander, Naval Base Norfolk) Date

1.0 SITE LOCATION AND DESCRIPTION

The Camp Allen Landfill is located approximately one mile east of Hampton Boulevard and one mile south of Willoughby Bay at the Naval Base Norfolk, Norfolk, Virginia. The Camp Allen Landfill Site and surrounding areas are illustrated in Figure 1-1. Landfilling operations commenced at the Camp Allen Landfill in the early 1940s and continued until approximately 1974. As shown in Figure 1-1, the Camp Allen Landfill is comprised of Area A (approximately 45 acres) and Area B (approximately 3 acres). In addition, source areas identified within Area A are designated as Area A1 and Area A2, as shown in Figure 1-1.

The Camp Allen Salvage Yard operation (scheduled to close in 1995) is located between Camp Allen Landfill Areas A and B. The salvage yard stores and recycles scrap such as wood, metal, appliances, abandoned cars, drums of various materials, and other types of surplus material.

The Camp Allen Landfill Site is located in mixed-use, urban land. Military facilities are located atop and/or adjacent to the landfill areas. Area A incorporates the Navy Brig facility and a heliport, which were built over a portion of the landfill during the mid-1970s. Glenwood Park (an off-base residential area) is located to the west of Area A. The Camp Allen Elementary School is located to the south of Area B, and the Capehart Military Housing Area is located south of the Camp Allen Elementary School. Various military activities, including USMC Camp Elmore operations, are conducted throughout the Camp Allen area.

At present, most of Area A and Area B is soil-covered and vegetated to minimize surface erosion. The area is surrounded by drainage ditches, which convey surface water runoff to Willoughby Bay. These drainage ditches are remnants of Bousch Creek, the main drainage channel, which was completely filled and replaced by a network of ditches and channels during the development of Naval Base Norfolk.

1.1 Physical Geography/Regional Geology

The Camp Allen Landfill Site and surrounding area can be characterized as a former tidal flat associated with the Bousch Creek drainage channel. The area was developed from marine sediments whose major constituents include sands, silts, and clays with considerable amounts of shell material and gravel.

The uppermost geologic unit and youngest formation is the Columbia Group; its average thickness ranges from 20 to 50 feet. The unconsolidated sediments are characterized by light-colored clay, sand, and silt. Monitoring wells installed at Camp Allen and in the vicinity confirm the sand depth to an average of 23 to 25 feet and dark clays, silts, and sands from 25 to 30 feet below ground surface. These later elements extend to the top of the Yorktown Formation. Surficial soils are primarily silts and clays that quickly grade into the sands and silts of the Columbia Group.

The Yorktown Formation underlies the Columbia Group, and is characterized by coarse sand, gravel, and abundant shell fragments. Regionally, the Yorktown Formation ranges in thickness from 300 to 400 feet. In the vicinity of the site, the Yorktown was encountered between 37 and 63 feet below grade and extends to a depth of approximately 130 feet.

1.2 Natural Resources

1.2.1 Surface Water

Surface water at Area A of the Camp Allen Landfill Site is primarily accommodated by two drainage ditches, which are remnants of Bousch Creek. Surface water from the site is eventually conveyed to Willoughby Bay through a main drainage channel, which begins at the northwest corner of Area A. Due to the proximity of this area to Willoughby Bay and the low relief of the land surface, the remnant tributaries of Bousch Creek are tidal throughout the Base. Surface water from the Camp Allen Salvage Yard, located between Areas A and B, is directed via storm sewers to the drainage ditch north of Area A.

Surface drainage at the Camp Allen Landfill Site is relatively poor in places, especially at Area B, due to the flatness of the area and silty/clayey nature of site surficial soils, which tend to retard infiltration. Patterns of surface drainage can be observed in Figure 1-2.

1.2.2 Groundwater

Two aquifer systems are impacted by the Camp Allen Landfill: the water table aquifer (Columbia Group) and the underlying Yorktown Aquifer (Yorktown Formation). The water table aquifer (shallow groundwater) is unconfined. The Yorktown Aquifer (deep groundwater) is separated from the water table aquifer by a confining clay unit. In the Camp Allen Area, a breach and/or ineffective (poorly developed) portion of the confining clay unit allows downward migration of constituents from the water table aquifer to the Yorktown Aquifer. Figure 1-3 presents generalized groundwater flow patterns for both the water table and Yorktown aquifer systems.

Groundwater on site currently is not used for any purpose. Potable water used on site and by the nearby community is supplied by the City of Norfolk, which obtains its water from a number of interconnected surface water sources (i.e., lakes, reservoirs and rivers) and from several groundwater wells during drought conditions. The shallow (water table) aquifer in the vicinity of the site is generally not suitable for potable (drinking water) use because of high concentrations of iron, manganese and suspended solids, as well as low pH (less than 6). In addition, a City of Norfolk ordinance does not allow potable use of the shallow aquifer. The water table aquifer is considered a Class 3 aquifer (i.e., not a potential source of drinking water and of limited beneficial use). The deeper Yorktown Aquifer is generally suitable for potable uses, except near tidal waters, which can cause the water to be brackish in quality. The Yorktown Aquifer is considered a Class 2 aquifer (i.e., current and potential sources of drinking water and waters having other beneficial uses). However, neither the water table nor Yorktown aquifers are used as a potable source on site or in the vicinity of the site.

Residential wells are present within Glenwood Park, located west of the Brig Facility, but are used only for nonpotable uses such as lawn watering, car washing and filling swimming pools. These wells reportedly are screened within the shallow (water table) aquifer. As a safety precaution, the residents in Glenwood Park were advised by the Navy to consider their private wells nonpotable. The deep groundwater (Yorktown Aquifer) in the vicinity of the site is also used for nonpotable purposes. Two currently inactive nonpotable wells, located approximately 1 mile northwest of the site, reportedly pumped about 100,000 gallons per day from the Yorktown Aquifer for use as process water.

1.2.3 Wetlands

Several types of wetlands have been identified in the vicinity of the site. Wetlands are an important natural resource because of their well-documented abilities in flood and soil erosion control. Wetlands also provide suitable habitat and cover for a variety of birds, reptiles, mammals, fish, and plants. The wetlands identified in the area of the Camp Allen Site are described as mostly a Palustrine system with a subsystem classification of Palustrine Scrub Shrub (PSS), Palustrine Emergent Wetland (PEM), and a Riverine Intermittent system with a Riverine stream bed subsystem (R4SB). Figure 1-4 depicts the most recently identified wetland areas near the Camp Allen Site. Each of these wetland areas has been assigned numbers 1 through 4 for identification purposes.

SECTION 1.0 FIGURES

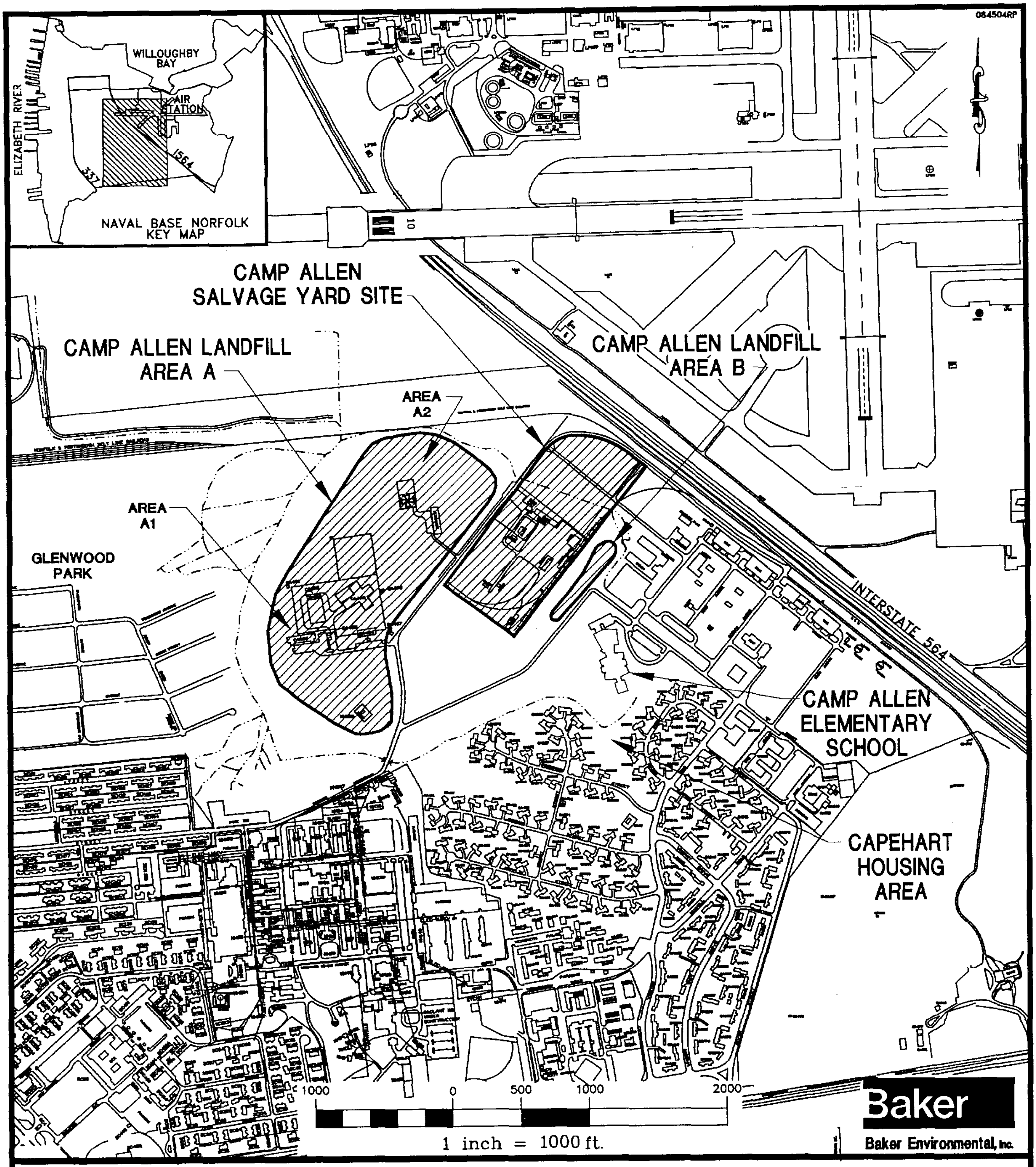
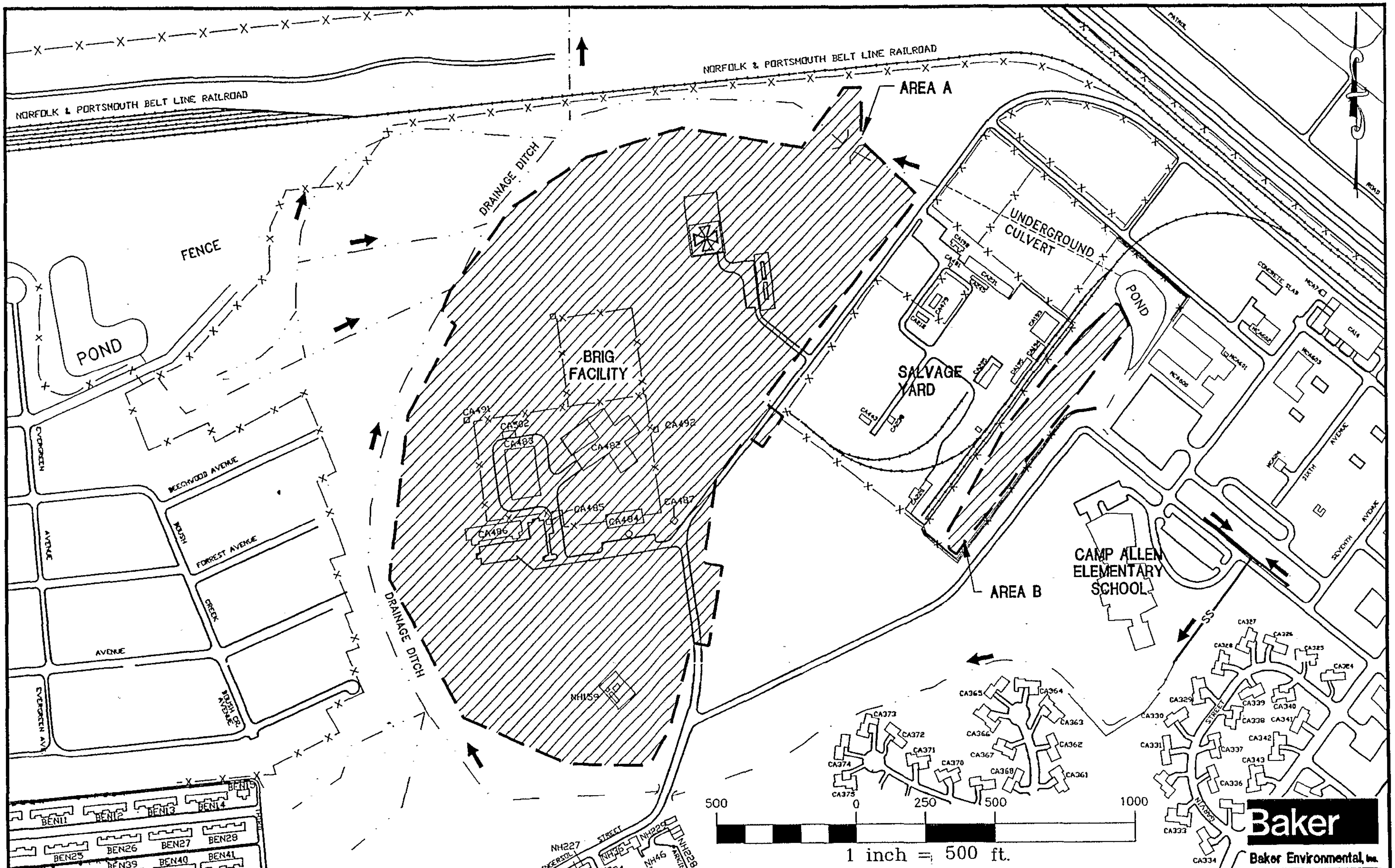


FIGURE 1-1
SITE MAP
CAMP ALLEN LANDFILL

NAVAL BASE NORFOLK
NORFOLK, VIRGINIA

SOURCE: LANTDIV, OCTOBER 1991



LEGEND

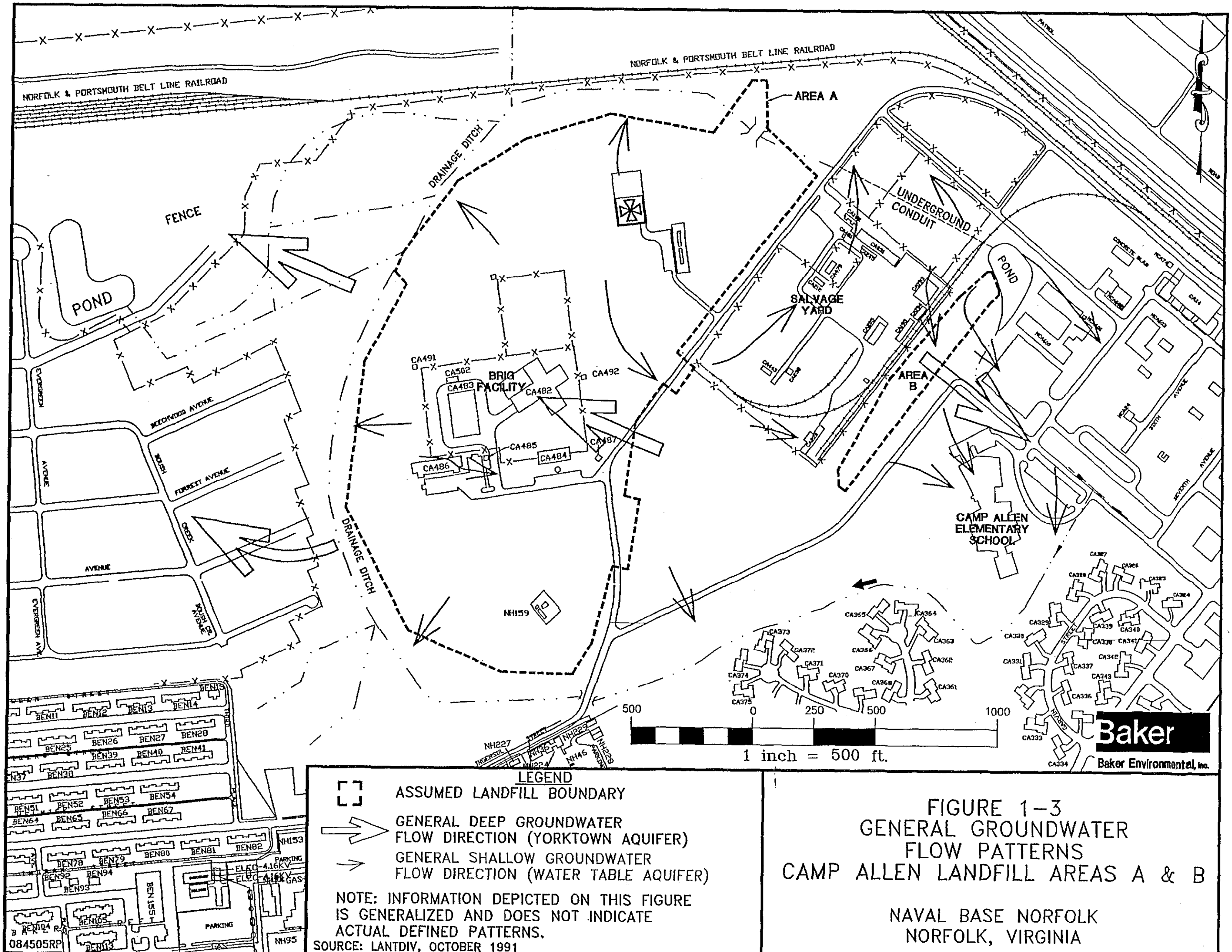
ASSUMED LANDFILL BOUNDARY

SURFACE WATER FLOW DIRECTION

SOURCE: LANTDIV, OCTOBER 1991

FIGURE 1-2
SURFACE DRAINAGE MAP
CAMP ALLEN LANDFILL AREAS A & B

NAVAL BASE NORFOLK
NORFOLK, VIRGINIA



LEGEND

ASSUMED LANDFILL BOUNDARY

GENERAL DEEP GROUNDWATER FLOW DIRECTION (YORKTOWN AQUIFER)

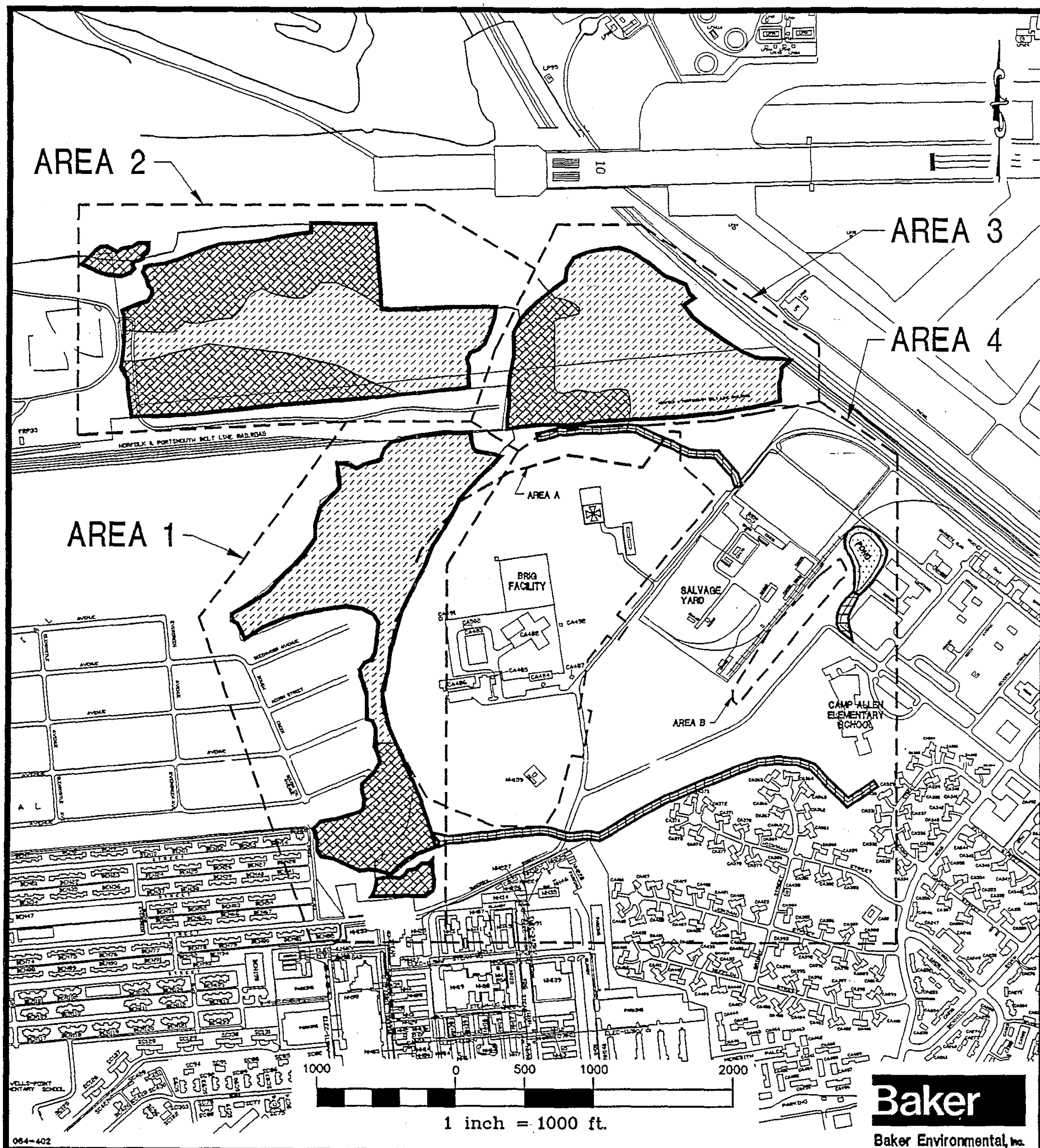
GENERAL SHALLOW GROUNDWATER FLOW DIRECTION (WATER TABLE AQUIFER)

NOTE: INFORMATION DEPICTED ON THIS FIGURE IS GENERALIZED AND DOES NOT INDICATE ACTUAL DEFINED PATTERNS.

SOURCE: LANTDIV, OCTOBER 1991

FIGURE 1-3
GENERAL GROUNDWATER FLOW PATTERNS
CAMP ALLEN LANDFILL AREAS A & B

NAVAL BASE NORFOLK
NORFOLK, VIRGINIA



LEGEND

PALUSTRINE EMERGENT WETLAND (PEM)

PALUSTRINE SCRUB SHRUB (PSS)

RIVERINE STREAM BED SUBSYSTEM (R4SB)

PALUSTRINE UNCONSOLIDATED BOTTOM (PUB)

SOURCE: USFWS/NATIONAL RESOURCE MANAGEMENT STAFF, ATLANTIC DIVISION, NAVAL FACILITIES ENGINEERING COMMAND

FIGURE 1-4
WETLAND LOCATION MAP
CAMP ALLEN LANDFILL

NAVAL BASE NORFOLK
NORFOLK, VIRGINIA

2.0 SITE HISTORY AND ENFORCEMENT ACTIVITIES

The regulatory basis of the site investigation, the land use history of the site, and the previous investigations which have been conducted at the site are briefly discussed below.

2.1 Installation Restoration Program

The Naval Base Norfolk currently is not on the National Priorities List (NPL), although it is expected to be placed on the NPL sometime in 1995. Therefore, there have been no enforcement activities at the site. The Camp Allen Landfill Site has been studied to date under the Installation Restoration Program (IRP).

The Camp Allen Landfill Site was identified during the IRP process as requiring investigation and evaluation of potentially hazardous materials. The following sections describe the history of the Camp Allen Landfill Site and summarize the results of previous investigations.

2.2 Site History

Area A of the Camp Allen Landfill is a 45-acre, grass-covered site that was used for the disposal of a variety of wastes. During the early 1940s, landfill operations commenced at the Camp Allen Landfill and continued until about 1974. Unknown various waste materials were disposed in Area A including demolition debris, sludges from metal plating processes, parts cleaning and paint stripping wastes, overage chemicals, various chlorinated organic solvents, acids, caustics, paints and paint thinners, pesticides, asbestos, and ash from an incinerator, which operated from the mid-1940s until the mid-1960s. Portions of the landfill now accommodate the Navy Brig Facility and a heliport.

Area B is a 3-acre landfill, which was used to dispose residue and debris resulting from a 1971 fire at the Camp Allen Salvage Yard.

2.3 Previous Investigations

Previous investigations of various hazardous waste sites at the Naval Base Norfolk (including the Camp Allen Landfill) were conducted and documented in an Initial Assessment. In addition, a Site Suitability Assessment, Confirmation Study, Interim Remedial Investigation Report, and an Interim Remedial Investigation have been conducted specifically for the Camp Allen Landfill Site. These investigations are briefly described below:

- Initial Assessment Study (IAS) (February 1983): In April 1982, an IAS was conducted at Sewell's Point Naval Complex at the Naval Base Norfolk. Based on review of historical records and general site reconnaissance, the Camp Allen Landfill was among the sites at the Naval Base Norfolk recommended for further study.

- Site Suitability Assessment (June 1984): Assessment activities were conducted for a proposed Brig Expansion from 1983 to 1984. The field investigation included a magnetometer survey, soil borings, and installation of 11 shallow groundwater monitoring wells and nine gas monitoring stations.

- Confirmation Study (April 1987): Six shallow and one deep groundwater monitoring wells were installed as part of the Confirmation Study. Existing wells were sampled, and surface water sampling was performed.

- Interim Remedial Investigation Report (March 1988): This interim report summarized Confirmation Study results for the Camp Allen Landfill. Additional field activities were not performed.

- Interim Remedial Investigation (1990-1991): A soil gas survey was performed in the vicinity of Area B. Nine shallow and six deep monitoring wells at Area A and eight shallow and three deep monitoring wells at Area B were installed. A week-long tidal study was performed in order to determine estimated influence on the groundwater regime. Groundwater was subsequently sampled from 26 new and 10 existing monitoring wells. A second round of samples was also collected from the nine deep wells. In addition, 55 residential wells in Glenwood Park were sampled for volatile organic compounds.

Surface water and sediment samples were collected and analyzed from adjacent drainage ditches at Area A and the pond at Area B.

- Remedial Investigation (1992-1993): A remedial investigation (RI) was performed to further assess the nature and extent of contamination at the Camp Allen Landfill Site. The following activities were performed:

  - Geophysical survey
  - Monitoring well installation and sampling
  - Surface soil sampling
  - Surface water and sediment sampling
  - Source characterization
  - Residential well sampling
  - Air monitoring of Navy Brig and Camp Allen Elementary School

  A summary of pertinent RI findings is presented in Section 5.1.

2.4 Removal and Remedial Actions

2.4.1 Area B Removal Action

Based on the RI findings, an Engineering Evaluation/Cost Analysis (EE/CA) (Baker, August 1993) for a non-time-critical removal action in Area B was performed to develop and evaluate alternatives for removal and disposal of contaminated subsurface soil and debris identified in former waste burial trenches at this location. The selected removal action alternative included:

- Excavation of the soil, debris, and buried drums from the trenches plus over-excavation of visibly-contaminated soil from the side walls and floor of the excavation;

- Confirmation soil sampling and analysis, and additional excavation of material contaminated in excess of the removal action cleanup levels;

- Disposal of excavated soil, debris, and drums at a RCRA-permitted hazardous waste disposal facility (landfill or incinerator).

The Area B removal action was initiated in the summer of 1994 and has been completed. The objective of the removal action was to remove the primary sources of groundwater contamination within the Area B Landfill so that no further remedial actions would be required for the soils and debris associated with the Area B Landfill. Confirmation soil sampling and analysis, as outlined in the Remedial Action Closeout Report (OHM, March 1995), verified that the soil cleanup levels were met as established in the Final EE/CA Report (Baker, August 1993). Therefore, the primary sources of contamination at Area B have been eliminated.

2.4.3 Remedial Design/Remedial Actions

In order to expedite the cleanup of contaminated soil and groundwater at the Camp Allen Landfill site, the DoN has proceeded with preliminary remedial design/remedial action (RD/RA) activities. Remedial design activities were initiated in the spring of 1994 and are expected to be completed in early 1995. The basis for the remedial design (groundwater and soil remediation) is summarized in the Final Basis of Design Report (Baker, May 1994). In addition, limited remedial action activities have been initiated at the site, including installation of groundwater extraction wells and performance of a DPVE pilot test in Areas A1 and A2 (OHM, December 1994).

Initially, DPVE was recommended for Areas A1 and A2 to provide source control in these "hot spot" areas of the Area A Landfill. As discussed herein, DPVE technology is no longer recommended for use in Area A2 based on the results of the DPVE pilot study. An alternative remediation approach, using submersible pumps to extract shallow groundwater, has been selected for Area A2. This approach, which was not initially proposed as an alternative in the FS, is now the preferred alternative for Area A2 groundwater. Therefore, an additional alternative (A2-GW4) has been added to accommodate the alternative remediation approach for Area A2 groundwater.

3.0 HIGHLIGHTS OF COMMUNITY PARTICIPATION

The Final Remedial Investigation (RI) (Baker, July 1994), Risk Assessment (RA) (Baker, November 1994), and Feasibility Study (FS) (Baker, November 1994) reports, as well as the Final Proposed Remedial Action Plan (PRAP) (Baker, March 1995) for the Camp Allen Landfill Site have been released and made available to the public in the Administrative Record at the Kirn Memorial Branch of the Norfolk Public Library in Norfolk, Virginia and at information repositories maintained at the Larchmont and Mary Pretlow Branches of the Norfolk Public Library and the Naval Station Library (Building C-9).

The notice of availability of the aforementioned documents was published in the Virginian-Pilot and Ledger Star on March 6, 1995. A public comment period was held from March 6, 1995 to April 5, 1995. In addition, a Restoration Advisory Board (RAB) meeting, in which the public was invited to attend, was held in Norfolk, Virginia on March 22, 1995. At this meeting, representatives from DoN discussed the remedial action alternatives currently under consideration and addressed community concerns. Response to the comments received during the public comment period and additional background information on community involvement for this project are presented in Section 11.0 of this document.

This Decision Document presents the selected response actions for the Camp Allen Landfill Site at Naval Base Norfolk in Norfolk, Virginia, which were chosen in accordance with CERCLA, as amended by SARA, and, to the extent practicable, the NCP. The selected decision for the Camp Allen Landfill Site is based on the Administrative Record.

4.0 SCOPE AND ROLE OF THE RESPONSE ACTION

The proposed response actions identified in this Decision Document address all contaminated media of concern at the site and comprise the overall cleanup strategy for the site. Contaminated media addressed by the proposed response actions include contaminated soil, surface water/sediment, and groundwater in Areas A and B. The recommended response actions (or preferred alternatives) for the various media and the rationale for their selection are described in Sections 7.0 through 9.0.

The principal threat posed by conditions at the Camp Allen Landfill Site is that contaminated soil in the Area A Landfill provides a continuing source of contamination, which threatens the underlying aquifers. The combination of proposed response actions is expected to address the principal threat posed by the site by providing effective source control and substantially reducing the potential for migration of contamination. The goals of the selected remedy are: (1) to prevent current or future exposure to the contaminated groundwater, soil, and surface water/sediment; (2) prevent further migration of contaminated groundwater and to remediate groundwater contamination for future potential beneficial uses of the aquifers; and (3) to treat contaminated soils in the areas of concern.

The selected remedial action authorized by this Decision Document addresses contaminated groundwater (shallow and deep) originating from the site through extraction and treatment, and through institutional controls to restrict groundwater use on site. Groundwater currently is not used for any purpose at the site; however, the groundwater poses a potential threat to human health and the environment because of the risks of possible ingestion under a future use scenario and potential off-site migration.

Area A soil also poses a risk to surface water and groundwater due to leaching of contaminants to those media. The selected remedial action addresses contaminated soil in Area A through in situ treatment. Contaminated soil, debris, and drums in Area B have been addressed through a removal action (see Section 2.4). Contaminated soil at the site does not pose a potential human health threat under the current land use scenario; however, the contaminated soils pose a potential threat to human health and the environment because of the risks of exposure to site soils under a future use scenario. The remedial actions for Areas A and B include institutional controls, which include maintenance of the existing fencing and deed restrictions to limit the areas to non-residential land use.

The selected remedial action is expected to comply with applicable or relevant and appropriate requirements (ARARs) and to be considered (TBC) requirements, which are federal and state environmental statutes that are either directly applicable or are considered in the development and evaluation of remedial alternatives at a particular site. Summaries of ARARs and TBCs for the Camp Allen Landfill Site are provided in Tables 10-1 and 10-2 in Section 10.0.

The selected remedial action proposes monitoring of surface water/sediment, but does not address contaminated surface water/sediment through removal or treatment for the following reasons:

- Relatively low levels of contaminants were detected in site surface water and sediments.

- Migration of contaminants from the surface water and sediments to groundwater is not considered to be a pathway of concern since shallow groundwater generally discharges to the drainage ditches (i.e., surface water generally does not recharge the shallow groundwater).

- Results of the baseline risk assessment for Area A and Area B surface water and sediment indicate no exceedances of human health criteria associated with exposure (via ingestion and dermal contact) to surface water or sediment under the current land uses. Therefore, under the current land uses at Areas A and B, no unacceptable human health effects would be expected from exposure to surface water and sediment.

- Source control measures that have been implemented at Area B (removal action), and source control measures that are planned for Area A, are expected to improve the quality of surface water and sediment in these areas over time.

Additional sampling/analysis of surface water/sediment is planned in the immediate future to determine the full extent of ecological impacts to the area surrounding the Camp Allen Landfill.

5.0 SUMMARY OF SITE CHARACTERISTICS

This section presents an overview of the nature and extent of contamination at Camp Allen Landfill with respect to known or suspected sources of contamination, types of contamination, and affected media.

5.1 Contamination and Affected Media

Contamination from prior disposal practices at Areas A and B of the Camp Allen Landfill has been detected in subsurface soils, surface soils, sediment, surface water, and groundwater (water table and Yorktown aquifer systems). Although various organic and inorganic contaminants were detected in site media, the primary constituents of concern at the site are volatile organic compounds (VOCs). Table 5-1 lists primary areas of detected contamination by media and area. Summaries of contaminants of potential concern (COPCs) by environmental media for various areas of the site are presented in Tables 5-2, 5-3, and 5-4. Highlights include source areas of VOCs in subsurface soils identified at or near the top of the water table aquifer in Area A and Area B. In isolated locations, wastes were identified beneath the water table. The following section summarizes the nature and extent of contamination at the Camp Allen Landfill, as established in the Camp Allen Landfill Final RI Report (Baker, July 1994).

Area A

- Subsurface soil: VOCs were the predominant contaminants detected in the subsurface soils at Area A. In general, two primary source locations were indicated. The first area appears to be located in the western portion of the Brig Facility. The second area appears to be located in the northern/northeastern region of Area A (north of the Brig Facility, near the helipad).

- Surface soil: Analytical results indicate surficial soil to be nominally impacted by disposal activities.

- Surface water: Results indicate isolated areas of VOCs and various inorganic constituent concentrations exceeding applicable standards/criteria.

- Sediment: Results indicate isolated areas of elevated levels of organic and inorganic constituent concentrations in small, sporadic areas of the drainage ditches surrounding the area.

- Groundwater: Two primary areas of VOC contamination were identified at Area A. The first area is located in the western portion of the Brig Facility (Area A1) and the second area is located along the north portion of the site near the helipad area (Area A2). Both shallow and deep groundwater contamination are present within these areas. Identified contaminants (primarily VOCs) appear to correspond to source areas mentioned above. Area A1 and Area A2 are shown in Figure 1-1.

- Residential well groundwater sampling: Analytical results indicate that site-related contaminants have not impacted the shallow (water table) groundwater in the Glenwood Park area. Shallow groundwater contamination appears to be limited to the western side of the Brig Facility (located east of Glenwood Park).

- Air sampling: No significant site-specific volatile air contaminants were detected.

<u>Area B</u>

- Subsurface soil: VOCs were the predominant contaminants detected in the subsurface soils at Area B. In general, the primary source area is located in the middle portion of the site within the landfill.

- Surface soil: Analytical results indicate surficial soil to be nominally impacted by disposal activities.

- Surface water: Results indicate areas of VOCs and various inorganic constituent concentrations exceeding applicable standards/criteria primarily in the eastern and northern portion of the ponded area.

- Sediment: Results indicate isolated areas of elevated levels of organic and inorganic constituent concentrations, primarily in the ponded area northeast of the site.

- Groundwater: The primary area of VOC contamination is located south/southeast of Area B. Both shallow and deep groundwater contamination are present within this area. Identified contaminants (primarily VOCs) correspond to the source area within the Area B landfill mentioned above.

- Residential wells: No residential wells reportedly are located in the vicinity of Area B.

- Air sampling: No significant site-specific volatile air contaminants were detected.

5.2 Location of Contamination (Based on Pre-Design Investigation)

The nature and extent of contamination, as determined by the Camp Allen Landfill RI, is summarized in Section 5.1. Additional activities that have been conducted since the RI that impact or further define the location/extent of contamination include the removal action in Area B, described in Section 2.4.1, and a pre-design investigation, which is described below.

In October 1993, Baker initiated a pre-design investigation to further delineate areas of groundwater and soil contamination to support remedial design efforts. Related pre-design activities included: in situ groundwater sampling (hydraulic drive points) and analysis of shallow groundwater in suspected source areas within Area A; well installation (shallow and deep) and groundwater sampling/analysis in Areas A and B; and, test pits in suspected source areas within Area A. The contaminants detected in soil and groundwater were similar to those found during the RI. Detailed information on the pre-design investigation can be found in the Remedial Design Work Plan (Baker, May 1994). A summary of pre-design investigation conclusions is presented below.

The results of the October 1993 groundwater sampling are shown in Figures 5-1 through 5-6 for Areas A1, A2, and B. Based on the well sampling results, the estimated downgradient edges of groundwater contamination in the water table aquifer in Areas A2 and B, and the deep (Yorktown) aquifer in Areas A1, A2 and B were revised as shown in Figure 5-7. Shallow groundwater contamination extends to the base of the water table aquifer, which is located approximately 20 to 30 feet below grade. Contamination in the Yorktown Aquifer generally extends to a depth of approximately 60 to 70 feet below grade.

The test pit investigation results are shown in Figures 5-8 and 5-9 for Areas A1 and A2, respectively. Based on the test pit investigation results and the soil cleanup goals (see Section 9.2.1), two primary source areas were identified in Area A. The source areas were designated Areas A1 and A2, as shown in Figures 5-10 and 5-11, respectively. These figures indicate the estimated extent of soil contamination in Areas A1 and A2. Based on this test pit investigation, the total volume of contaminated soil was estimated to be approximately 12,800 cubic yards.

5.3 Potential Migration Pathways

The threat of contaminant migration from Area B soil has been essentially eliminated by the Area B removal action. The principal threat at the Camp Allen Landfill Site is posed by contaminated soil in the Area A Landfill, which provides a potential source of contamination to the underlying aquifers. Currently, potable water throughout Camp Allen and the surrounding area is supplied by the City of Norfolk. Residential wells in Glenwood Park, located west of Area A, supply water for nonpotable uses only. Although groundwater at the site currently is not used for any purpose, contaminated groundwater at the site could pose a human health risk if utilized as a drinking water source under a potential future residential use scenario.

Migration of contaminants from the surface water and sediments to groundwater is not considered to be a pathway of concern since shallow groundwater generally discharges to the drainage ditches (i.e., surface water generally does not recharge the shallow groundwater). Source control measures that have been implemented at Area B (removal action), and that are planned for Area A, are expected to improve the quality of surface water and sediment in these areas over time.

The combination of proposed response actions for this site is expected to provide effective source control and substantially reduce the potential for migration of contamination, which will reduce potential human health and environmental risks.

SECTION 5.0 TABLES

TABLE 5-1

SUMMARY OF RI FINDINGS

Media	Area A	Area B
Subsurface Soil	VOCs ● West of Brig Facility ● North of Brig Facility	VOCs ● Middle portion of Area B
Surface Soil	Nominal findings	Nominal findings
Sediment	VOCs ● Northwest drainage ditch (Area B related)	VOCs ● Ponded area
	Metals ● Northeast drainage ditch (Area B related) (various constituents) ● Northern drainage ditch (various constituents) ● Northwestern drainage ditch (mercury plus others)	Metals ● Ponded area (mercury plus others)
Surface Water	VOCs ● Northwest drainage ditch (Area B related)	VOCs ● Ponded area
	Metals ● Throughout Area A (various constituents)	Metals ● Ponded area ● Throughout drainage ditches
Shallow Groundwater	VOCs ● West of Brig Facility ● North of Brig Facility	VOCs ● South/southeast of Area B
Deep Groundwater	VOCs ● West of Brig Facility ● North of Brig Facility	VOCs ● Underneath Area B

TABLE 5-2

SUMMARY OF COPCs BY ENVIRONMENTAL MEDIUM
AND MAXIMUM DETECTED CONCENTRATIONS(1)
AREA A LANDFILL
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE, NORFOLK, VIRGINIA

COPCs	Surface Soil (µg/kg)	Subsurface Soil (µg/kg)	Shallow Groundwater (µg/L)	Deep Groundwater (µg/L)	Surface Water (µg/L)	Shallow Sediment (µg/kg)	Deep Sediment (µg/kg)
Volatile Organic Compounds:							
Benzene	--	--	310J	3J	--	--	--
Bromomethane	--	--	--	--	--	--	--
2-Butanone	--	--	4,300	--	--	--	--
Chlorobenzene	--	--	--	--	--	--	--
Chloroform	--	--	--	8	--	--	--
Chloromethane	--	--	--	--	--	--	--
1,4-Dichlorobenzene	--	--	--	--	--	--	--
1,2-Dichloroethane	--	--	3J	38J	--	--	--
1,1-Dichloroethene	--	--	--	--	--	--	--
1,2-Dichloroethene	--	--	6,100	540	--	--	--
4-Methyl-2-pentanone	--	--	16,000	--	--	--	--
Methylene chloride	--	--	57J	--	--	--	--

TABLE 5-2 (Continued)

SUMMARY OF COPCs BY ENVIRONMENTAL MEDIUM
AND MAXIMUM DETECTED CONCENTRATIONS[1]
AREA A LANDFILL
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE, NORFOLK, VIRGINIA

COPCs	Surface Soil (µg/kg)	Subsurface Soil (µg/kg)	Shallow Groundwater (µg/L)	Deep Groundwater (µg/L)	Surface Water (µg/L)	Shallow Sediment (µg/kg)	Deep Sediment (µg/kg)
Volatile Organic Compounds (Continued): Tetrachloroethene	--	--	620	4	6J	--	--
Toluene	--	3,000,000	5,400	--	--	--	--
1,1,1-Trichloroethane	--	--	--	--	--	--	--
Trichloroethene	--	--	1,800	100	20	--	--
1,2,4-Trimethylbenzene	--	--	--	--	--	--	--
1,3,5-Trimethylbenzene	--	--	--	--	--	--	--
Benzyl chloride	--	--	--	--	--	--	--
Vinyl chloride	--	--	3,300	100	6J	--	--
Total Xylenes	--	--	--	--	3J	--	--
Semivolatile Organic Compounds: Hexachlorobutadiene	--	--	--	--	--	--	--

TABLE 5-2 (Continued)

SUMMARY OF COPCs BY ENVIRONMENTAL MEDIUM
AND MAXIMUM DETECTED CONCENTRATIONS[1]
AREA A LANDFILL
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE, NORFOLK, VIRGINIA

COPCs	Surface Soil (μg/kg)	Subsurface Soil (μg/kg)	Shallow Groundwater (μg/L)	Deep Groundwater (μg/L)	Surface Water (μg/L)	Shallow Sediment (μg/kg)	Deep Sediment (μg/kg)
Semivolatile Organic Compounds: (Continued) 2-Methylphenol	--	--	1,800J	--	--	--	--
2,4-Dimethylphenol	--	--	1,400J	--	--	--	--
4-Methylphenol	--	--	21,000	--	--	--	--
Bis(2-ethylhexyl)phthalate	--	--	13	--	3J	--	--
Bis(2-chloroethyl)ether	--	--	--	2J	--	--	--
Acenaphthene	--	--	--	--	--	--	4,100
Pesticides: Aldrin	--	--	0.026J	--	--	--	--
alpha-Chlordane	--	--	--	--	0.015J	--	--
delta-BHC	--	--	--	--	0.025J	--	--
gamma-BHC (Lindane)	--	--	--	--	--	--	--

TABLE 5-2 (Continued)

SUMMARY OF COPCs BY ENVIRONMENTAL MEDIUM
AND MAXIMUM DETECTED CONCENTRATIONS[1]
AREA A LANDFILL
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE, NORFOLK, VIRGINIA

COPCs	Surface Soil (μg/kg)	Subsurface Soil (μg/kg)	Shallow Groundwater (μg/L)	Deep Groundwater (μg/L)	Surface Water (μg/L)	Shallow Sediment (μg/kg)	Deep Sediment (μg/kg)
Pesticides (Continued): 4,4'-DDD	--	--	--	--	0.26L	--	--
4,4'-DDE	--	--	--	--	0.069J	110	85
4,4'-DDT	--	--	--	--	--	73L	--
Dieldrin	--	89K	--	--	0.027J	--	62
gamma-Chlordane	--	--	--	--	0.024J	--	--
Heptachlor epoxide	--	--	0.14L	0.0065J	0.006J	--	--
Polychlorinated Biphenyls: Aroclor-1254	--	1,600	--	--	0.44J	--	980
Aroclor-1260	420L	1,800	--	--	--	1,500	--
Metals (2): Aluminum	9,880	--	132,000 (-)	49,600 (-)	20,300J	--	--
Antimony	--	--	31 (-)	-- (-)	--	--	--

TABLE 5-2 (Continued)

SUMMARY OF COPCs BY ENVIRONMENTAL MEDIUM
AND MAXIMUM DETECTED CONCENTRATIONS[1]
AREA A LANDFILL
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE, NORFOLK, VIRGINIA

COPCs	Surface Soil (µg/kg)	Subsurface Soil (µg/kg)	Shallow Groundwater (µg/L)	Deep Groundwater (µg/L)	Surface Water (µg/L)	Shallow Sediment (µg/kg)	Deep Sediment (µg/kg)
Metals (Continued): Arsenic	70	--	309 (200L)	64.35L (4.9)	64.2	590	71
Barium	1,050J	--	7,270 (6,060)	(-)	409	--	--
Beryllium	--	--	10.6 (-)	-- (-)	--	--	--
Cadmium	88.9	--	45.9 (-)	6.5 (-)	--	160	180
Chromium	121	--	353 (-)	165.5 (-)	--	3,000	1,700
Copper	477	--	356 (-)	-- (-)	--	553J	--
Lead	683	--	381L (1.6)	44.2 (-)	800	1,000	540
Manganese	128	--	2,060J (2,630)	2,170 (284)	697	51.2	50.7
Mercury	--	--	(-)	(-)	3.9	3	1.1

TABLE 5-2 (Continued)

SUMMARY OF COPCs BY ENVIRONMENTAL MEDIUM
AND MAXIMUM DETECTED CONCENTRATIONS[1]
AREA A LANDFILL
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE, NORFOLK, VIRGINIA

COPCs	Surface Soil (µg/kg)	Subsurface Soil (µg/kg)	Shallow Groundwater (µg/L)	Deep Groundwater (µg/L)	Surface Water (µg/L)	Shallow Sediment (µg/kg)	Deep Sediment (µg/kg)
Nickel	--	--	352	-- (-)	--	--	--
Silver	--	--	-- (-)	-- (-)	12	110	49
Thallium	0.92	--	-- (-)	6L (-)	--	--	--
Vanadium	78.7	--	396 (-)	355.5 (-)	--	180	74
Zinc	--	--	-- (-)	-- (-)	1,860J	--	542K

Notes:

(1) Maximum detected concentrations are presented only for those constituents retained as COPCs in the Revised Final Human Health Risk Assessment.
(2) Maximum detected concentrations presented for metals in soils and sediments are in units of mg/kg.
-- Not retained as a COPC for the respective environmental medium in the Revised Final Human Health Risk Assessment.
() = Concentration or "--" in parentheses is for dissolved (filtered) constituent in groundwater.
J Value estimated
K Estimated value, biased high
L Estimated value, biased low

TABLE 5-3

SUMMARY OF COPCs BY ENVIRONMENTAL MEDIUM
AND MAXIMUM DETECTED CONCENTRATIONS[1]
AREA B LANDFILL AND POND
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE, NORFOLK, VIRGINIA

COPCs	Surface Soil (µg/kg)	Subsurface Soil (µg/kg)	Shallow Groundwater (µg/L)	Deep Groundwater (µg/L)	Surface Water (µg/L)	Shallow Sediment (µg/kg)	Deep Sediment (µg/kg)
Volatile Organic Compounds:							
Benzene	--	--	410	12	12	--	--
Bromomethane	--	--	--	--	--	--	--
2-Butanone	--	--	48	--	--	--	--
Chlorobenzene	--	--	--	--	--	--	--
Chloroform	--	--	--	1J	24	--	--
Chloromethane	--	--	--	--	--	--	--
1,4-Dichlorobenzene	--	--	3J	--	--	--	--
1,2-Dichloroethane	--	--	180	450	8J	--	--
1,1-Dichloroethene	--	--	51	--	--	--	--
1,2-Dichloroethene	--	--	1,600	16	--	--	--
4-Methyl-2-pentanone	--	--	--	--	--	--	--
Methylene chloride	--	--	--	--	--	--	--

TABLE 5-3 (Continued)

SUMMARY OF COPCs BY ENVIRONMENTAL MEDIUM
AND MAXIMUM DETECTED CONCENTRATIONS[1]
AREA B LANDFILL AND POND
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE, NORFOLK, VIRGINIA

COPCs	Surface Soil (µg/kg)	Subsurface Soil (µg/kg)	Shallow Groundwater (µg/L)	Deep Groundwater (µg/L)	Surface Water (µg/L)	Shallow Sediment (µg/kg)	Deep Sediment (µg/kg)
Volatile Organic Compounds (Continued): Tetrachloroethene	--	--	10J	--	--	--	--
Toluene	--	--	--	--	--	--	--
1,1,1-Trichloroethane	--	--	--	--	--	--	--
Trichloroethene	--	3,100	520	35	45	--	--
1,2,4-Trimethylbenzene	--	--	--	--	--	--	--
1,3,5-Trimethylbenzene	--	--	--	--	--	--	--
Benzyl chloride	--	--	--	--	--	--	--
Vinyl chloride	--	16	940J	3	22	60	10J
Total Xylenes	--	--	--	--	--	--	--
Semivolatile Organic Compounds: Hexachlorobutadiene	--	--	--	--	--	--	--

TABLE 5-3 (Continued)

SUMMARY OF COPCs BY ENVIRONMENTAL MEDIUM
AND MAXIMUM DETECTED CONCENTRATIONS[1]
AREA B LANDFILL AND POND
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE, NORFOLK, VIRGINIA

COPCs	Surface Soil (µg/kg)	Subsurface Soil (µg/kg)	Shallow Groundwater (µg/L)	Deep Groundwater (µg/L)	Surface Water (µg/L)	Shallow Sediment (µg/kg)	Deep Sediment (µg/kg)
Semivolatile Organic Compounds: (Continued) 2-Methylphenol	--	--	--	--	--	--	--
2,4-Dimethylphenol	--	--	--	--	--	--	--
4-Methylphenol	--	--	--	--	--	--	--
Bis(2-ethylhexyl)phthalate	--	--	5J	--	9J	--	--
Bis(2-chloroethyl)ether	--	--	8J	--	--	--	--
Acenaphthene	--	--	--	--	--	--	--
Pesticides: Aldrin	--	--	--	--	--	--	--
alpha-Chlordane	--	--	--	--	--	--	--
delta-BHC	--	--	--	--	--	--	--
gamma-BHC (Lindane)	--	--	0.15	--	--	--	--

TABLE 5-3 (Continued)

SUMMARY OF COPCs BY ENVIRONMENTAL MEDIUM
AND MAXIMUM DETECTED CONCENTRATIONS(1)
AREA B LANDFILL AND POND
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE, NORFOLK, VIRGINIA

COPCs	Surface Soil (µg/kg)	Subsurface Soil (µg/kg)	Shallow Groundwater (µg/L)	Deep Groundwater (µg/L)	Surface Water (µg/L)	Shallow Sediment (µg/kg)	Deep Sediment (µg/kg)
Pesticides (Continued): 4,4'-DDD	--	3,800	--	--	--	4,200	--
4,4'-DDE	--	--	--	--	--	850	60L
4,4'-DDT	--	--	--	--	--	--	4,400
Dieldrin	--	1,500	0.043J	0.009J	--	86K	--
gamma-Chlordane	--	--	--	--	--	--	--
Heptachlor epoxide	--	--	0.006J	0.0105J	--	--	--
Polychlorinated Biphenyls: Aroclor-1254	--	9,500	--	--	--	7,600	--
Aroclor-1260	780L	--	--	--	--	--	--
Metals (2): Aluminum	--	15,500	192,000 (-)	146,000 (-)	690	--	--
Antimony	--	8L	28.7 (32.9)	25.2L (-)	--	16L	--

TABLE 5-3 (Continued)

SUMMARY OF COPCs BY ENVIRONMENTAL MEDIUM
AND MAXIMUM DETECTED CONCENTRATIONS[1]
AREA B LANDFILL AND POND
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE, NORFOLK, VIRGINIA

COPCs	Surface Soil (μg/kg)	Subsurface Soil (μg/kg)	Shallow Groundwater (μg/L)	Deep Groundwater (μg/L)	Surface Water (μg/L)	Shallow Sediment (μg/kg)	Deep Sediment (μg/kg)
Metals (Continued): Arsenic	11.6	60.5J	93.6 (16.4)	194L (1.3)	6.7	42.7	--
Barium	--	1,480	1,740 (-)	596 (-)	--	--	--
Beryllium	--	5.6	18.5 (-)	11.2 (-)	--	0.76	0.56
Cadmium	20.5	--	17.8 (-)	30.8 (-)	--	41.9	12
Chromium	44.3	--	774.5 (22.2)	542K (-)	--	--	--
Copper	--	--	380 (-)	225 (-)	--	298	--
Lead	--	--	1,020 (-)	183 (-)	15.8	497J	--
Manganese	102	63.5	4,880 (1,385)	4,740K (356)	272	246	69.6

TABLE 5-3 (Continued)

SUMMARY OF COPCs BY ENVIRONMENTAL MEDIUM
AND MAXIMUM DETECTED CONCENTRATIONS[1]
AREA B LANDFILL AND POND
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE, NORFOLK, VIRGINIA

COPCs	Surface Soil (µg/kg)	Subsurface Soil (µg/kg)	Shallow Groundwater (µg/L)	Deep Groundwater (µg/L)	Surface Water (µg/L)	Shallow Sediment (µg/kg)	Deep Sediment (µg/kg)
Mercury	--	--	3 (-)	-- (-)	--	0.35K	--
Nickel	--	--	433 (-)	203 (-)	--	--	--
Silver	--	--	-- (-)	-- (-)	--	14.7	--
Thallium	--	2	-- (-)	-- (-)	--	--	--
Vanadium	--	149	1,610 (29.9)	769K (-)	--	130	--
Zinc	--	--	1,550 (-)	-- (-)	202	1,020	--

Notes:

(1) Maximum detected concentrations are presented only for those constituents retained as COPCs in the Revised Final Human Health Risk Assessment.

(2) Maximum detected concentrations presented for metals in soils and sediments are in units of mg/kg.

-- Not retained as a COPC for the respective environmental medium in the Revised Final Human Health Risk Assessment.

() = Concentration or "--" in parentheses is for dissolved (filtered) constituent in groundwater.

J Value estimated

K Estimated value, biased high

L Estimated value, biased low

TABLE 5-4

SUMMARY OF COPCs BY ENVIRONMENTAL MEDIUM
AND MAXIMUM DETECTED CONCENTRATIONS[1]
AREA B - ELEMENTARY SCHOOL
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE, NORFOLK, VIRGINIA

COPCs	Surface Soil (μg/kg)	Subsurface Soil (μg/kg)	Shallow Groundwater (μg/L)	Deep Groundwater (μg/L)	Surface Water (μg/L)	Shallow Sediment (μg/kg)	Deep Sediment (μg/kg)
Volatile Organic Compounds: Benzene	--	--	410	12	--	--	--
Bromomethane	--	--	--	--	--	--	--
2-Butanone	--	--	48	--	--	--	--
Chlorobenzene	--	--	--	--	--	--	--
Chloroform	--	--	--	1J	--	--	--
Chloromethane	--	--	--	--	--	--	--
1,4-Dichlorobenzene	--	--	3J	--	--	--	--
1,2-Dichloroethane	--	--	180	450	--	--	--
1,1-Dichloroethene	--	--	51	--	--	--	--
1,2-Dichloroethene	--	--	1,600	16	--	--	--
4-Methyl-2-pentanone	--	--	--	--	--	--	--
Methylene chloride	--	--	--	--	--	--	--

TABLE 5-4 (Continued)

SUMMARY OF COPCs BY ENVIRONMENTAL MEDIUM
AND MAXIMUM DETECTED CONCENTRATIONS[1]
AREA B - ELEMENTARY SCHOOL
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE, NORFOLK, VIRGINIA

COPCs	Surface Soil (µg/kg)	Subsurface Soil (µg/kg)	Shallow Groundwater (µg/L)	Deep Groundwater (µg/L)	Surface Water (µg/L)	Shallow Sediment (µg/kg)	Deep Sediment (µg/kg)
Volatile Organic Compounds (Continued): Tetrachloroethene	--	--	10J	--	--	--	--
Toluene	--	--	--	--	--	--	--
1,1,1-Trichloroethane	--	--	--	--	--	--	--
Trichloroethene	--	3,100	520	35	--	--	--
1,2,4-Trimethylbenzene	--	--	--	--	--	--	--
1,3,5-Trimethylbenzene	--	--	--	--	--	--	--
Benzyl chloride	--	--	--	--	--	--	--
Vinyl chloride	--	16	940J	3	--	--	--
Total Xylenes	--	--	--	--	--	--	--
Semivolatile Organic Compounds: Hexachlorobutadiene	--	--	--	--	--	--	--

TABLE 5-4 (Continued)

SUMMARY OF COPCs BY ENVIRONMENTAL MEDIUM
AND MAXIMUM DETECTED CONCENTRATIONS[1]
AREA B - ELEMENTARY SCHOOL
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE, NORFOLK, VIRGINIA

COPCs	Surface Soil (µg/kg)	Subsurface Soil (µg/kg)	Shallow Groundwater (µg/L)	Deep Groundwater (µg/L)	Surface Water (µg/L)	Shallow Sediment (µg/kg)	Deep Sediment (µg/kg)
Semivolatile Organic Compounds: (Continued) 2-Methylphenol	--	--	--	--	--	--	--
2,4-Dimethylphenol	--	--	--	--	--	--	--
4-Methylphenol	--	--	--	--	--	--	--
Bis(2-ethylhexyl)phthalate	--	--	5J	--	--	--	--
Bis(2-chloroethyl)ether	--	--	8J	--	--	--	--
Acenaphthene	--	--	--	--	--	--	--
Pesticides: Aldrin	--	--	--	--	--	--	--
alpha-Chlordane	--	--	--	--	--	--	--
delta-BHC	--	--	--	--	--	--	--
gamma-BHC (Lindane)	--	--	0.15	--	--	--	--

TABLE 5-4 (Continued)

SUMMARY OF COPCs BY ENVIRONMENTAL MEDIUM
AND MAXIMUM DETECTED CONCENTRATIONS[1]
AREA B - ELEMENTARY SCHOOL
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE, NORFOLK, VIRGINIA

COPCs	Surface Soil (µg/kg)	Subsurface Soil (µg/kg)	Shallow Groundwater (µg/L)	Deep Groundwater (µg/L)	Surface Water (µg/L)	Shallow Sediment (µg/kg)	Deep Sediment (µg/kg)
Pesticides (Continued): 4,4'-DDD	--	3,800	--	--	0.038J	--	--
4,4'-DDE	--	--	--	--	--	--	--
4,4'-DDT	--	--	--	--	--	--	--
Dieldrin	--	1,500	0.043J	0.009J	--	--	--
gamma-Chlordane	--	--	--	--	--	--	--
Heptachlor epoxide	--	--	0.006J	0.0105J	--	--	--
Polychlorinated Biphenyls: Aroclor-1254	--	9,500	--	--	--	--	--
Aroclor-1260	--	--	--	--	--	--	--
Metals (2): Aluminum	--	15,500	192,000 (-)	146,000 (-)	--	--	--
Antimony	7.8L	8L	28.7 (32.9)	25.2L (-)	--	--	--

TABLE 5-4 (Continued)

SUMMARY OF COPCs BY ENVIRONMENTAL MEDIUM
AND MAXIMUM DETECTED CONCENTRATIONS(1)
AREA B - ELEMENTARY SCHOOL
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE, NORFOLK, VIRGINIA

COPCs	Surface Soil (µg/kg)	Subsurface Soil (µg/kg)	Shallow Groundwater (µg/L)	Deep Groundwater (µg/L)	Surface Water (µg/L)	Shallow Sediment (µg/kg)	Deep Sediment (µg/kg)
Metals (Continued): Arsenic	25.1L	60.5J	93.6 (16.4)	194L (1.3)	11.5K	--	--
Barium	--	1,480	1,740 (-)	596 (-)	--	--	--
Beryllium	--	5.6	18.5 (-)	11.2 (-)	--	--	--
Cadmium	--	--	17.8 (-)	30.8 (-)	--	--	--
Chromium	869	--	774.5 (22.2)	542K (-)	--	--	--
Copper	--	--	380 (-)	225 (-)	--	--	--
Lead	--	--	1,020 (-)	183 (-)	53.6	--	310
Manganese	61.2	63.5	4,880 (1,385)	4,740K (1,356)	574	--	--

TABLE 5-4 (Continued)

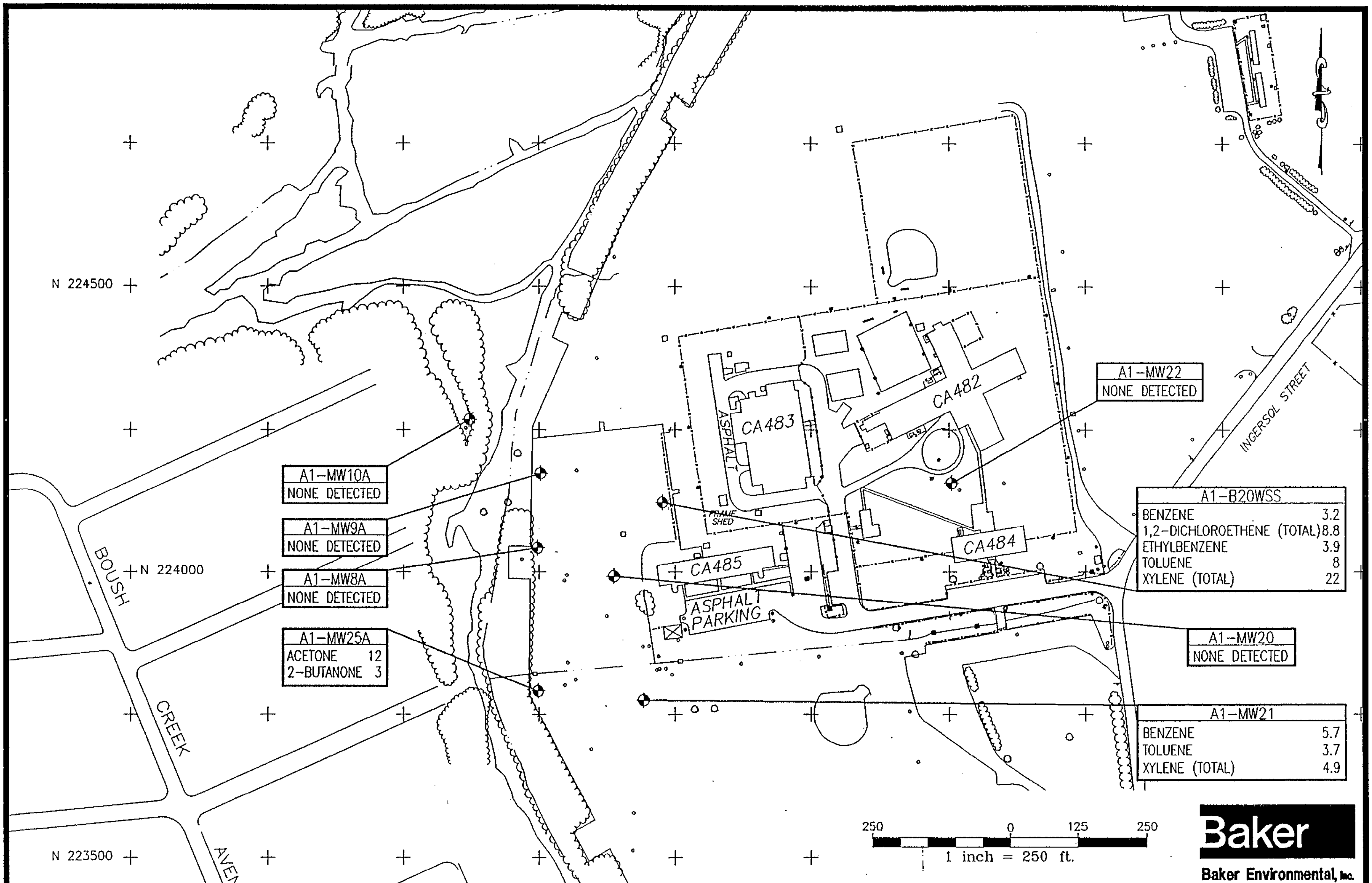
SUMMARY OF COPCs BY ENVIRONMENTAL MEDIUM AND MAXIMUM DETECTED CONCENTRATIONS[1]
AREA B - ELEMENTARY SCHOOL
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE, NORFOLK, VIRGINIA

COPCs	Surface Soil (µg/kg)	Subsurface Soil (µg/kg)	Shallow Groundwater (µg/L)	Deep Groundwater (µg/L)	Surface Water (µg/L)	Shallow Sediment (µg/kg)	Deep Sediment (µg/kg)
Mercury	--	--	3 (-)	-- (-)	--	--	0.8
Nickel	--	--	433 (-)	203 (-)	--	--	--
Silver	--	--	-- (-)	-- (-)	--	--	--
Thallium	--	2	-- (-)	-- (-)	--	--	--
Vanadium	128	149	1,610 (29.9)	769K (-)	--	--	--
Zinc	--	--	1,550 (-)	-- (-)	199J	--	--

Notes:

(1) Maximum detected concentrations (based on RI sampling Rounds 2 and 3) are presented only for those constituents retained as COPCs in the Revised Final Human Health Risk Assessment (Baker, February 1995).
(2) Maximum detected concentrations presented for metals in soils and sediments are in units of mg/kg.
-- Not retained as a COPC for the respective environmental medium in the Revised Final Human Health Risk Assessment (Baker, February 1995).
() = Concentration or "--" in parentheses is for dissolved (filtered) constituent in groundwater.
J Value estimated
K Estimated value, biased high
L Estimated value, biased low

SECTION 5.0 FIGURES



LEGEND

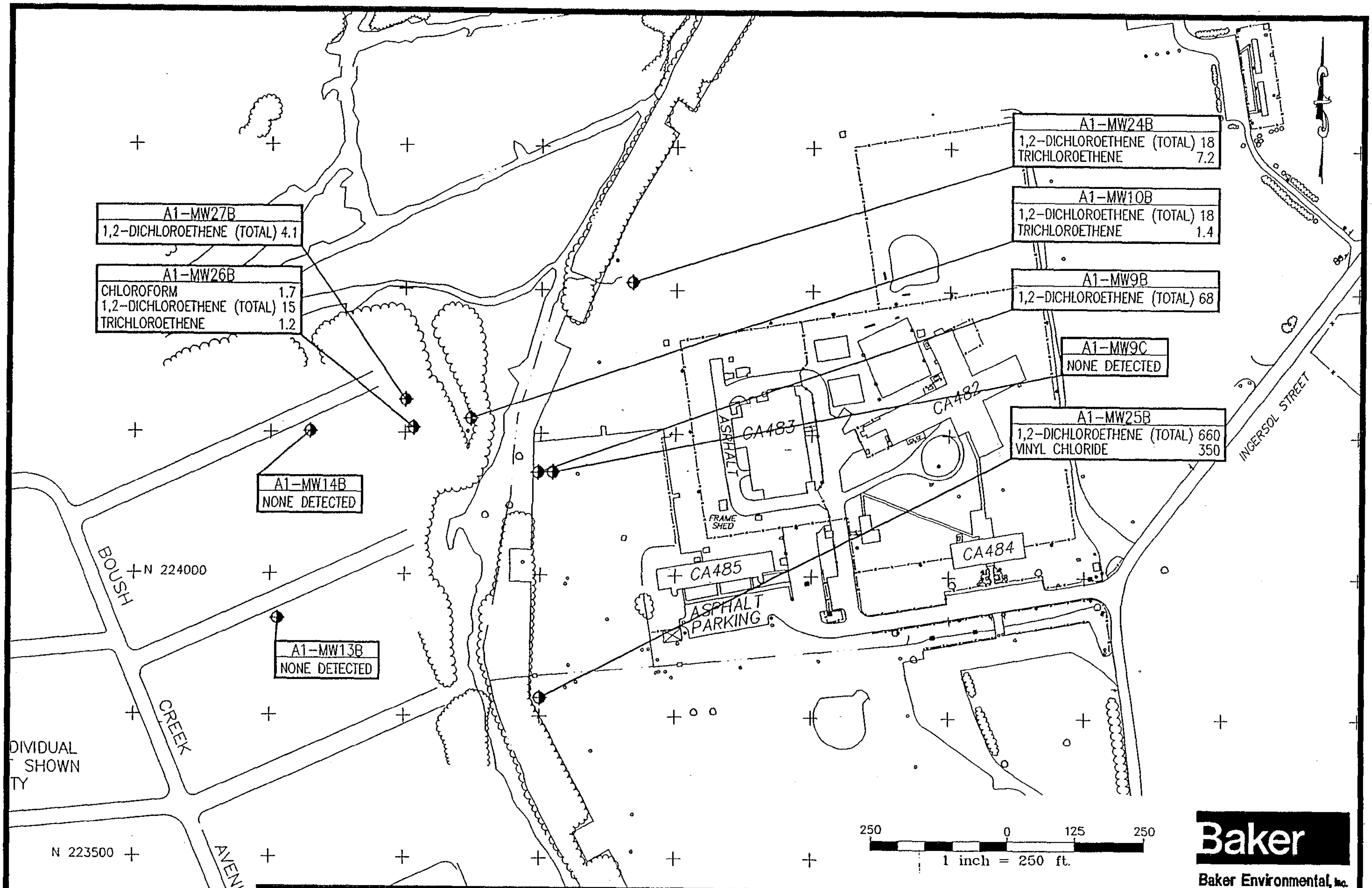
⊕ SHALLOW MONITORING WELL

NOTE: ALL CONCENTRATIONS IN ug/L.

SOURCE: MILLER-STEPHENSON & ASSOC. JUNE 1992

084510FS

FIGURE 5-1
AREA A1 SHALLOW GROUNDWATER
VOLATILES RESULTS
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE
NORFOLK, VIRGINIA



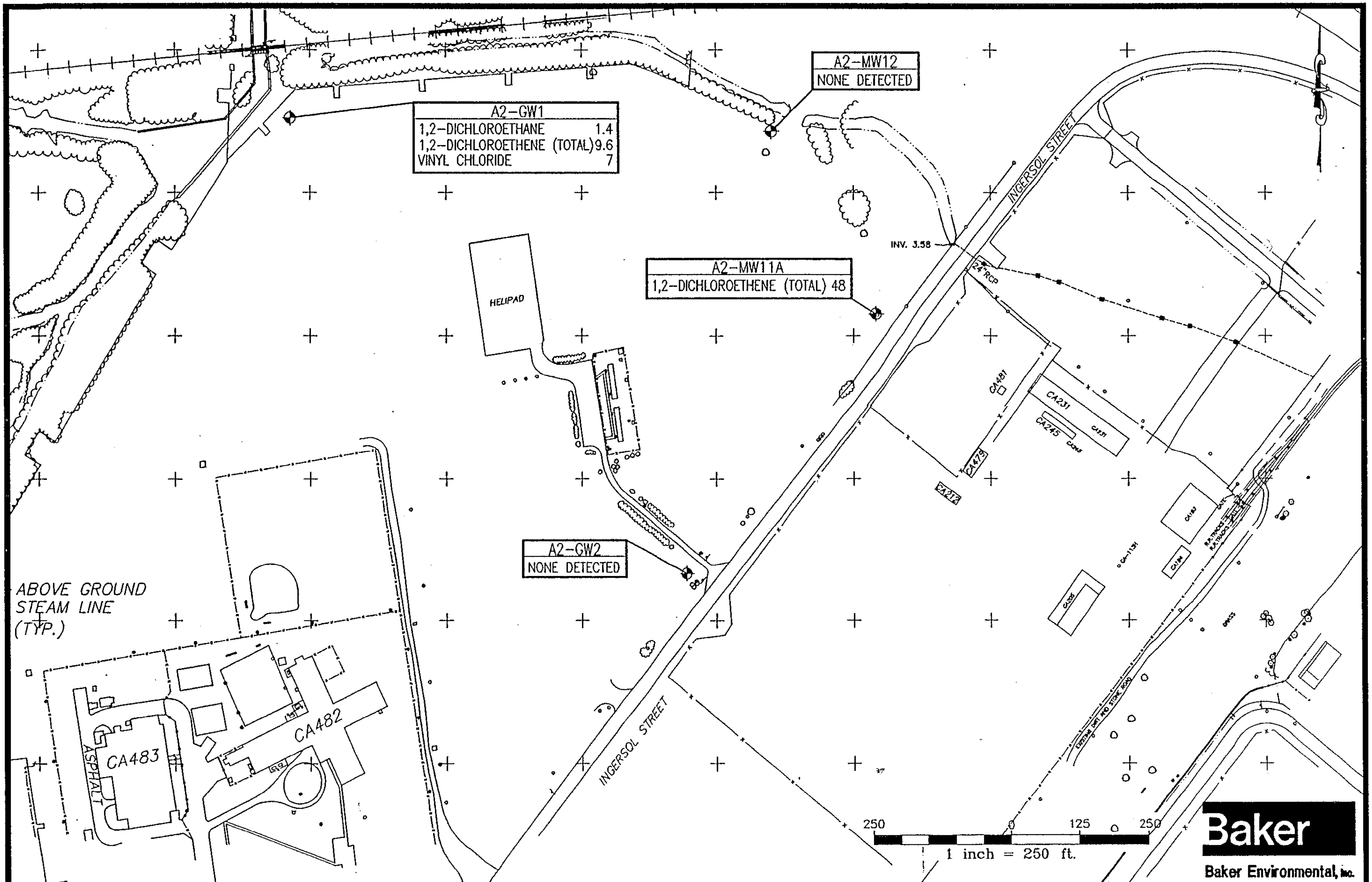
LEGEND

DEEP MONITORING WELL

NOTE: ALL CONCENTRATIONS IN ug/L.

SOURCE: MILLER-STEPHENSON & ASSOC. JUNE 1992

FIGURE 5-2
AREA A1 DEEP GROUNDWATER
VOLATILES RESULTS
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE
NORFOLK, VIRGINIA



LEGEND

⊕ SHALLOW MONITORING WELL

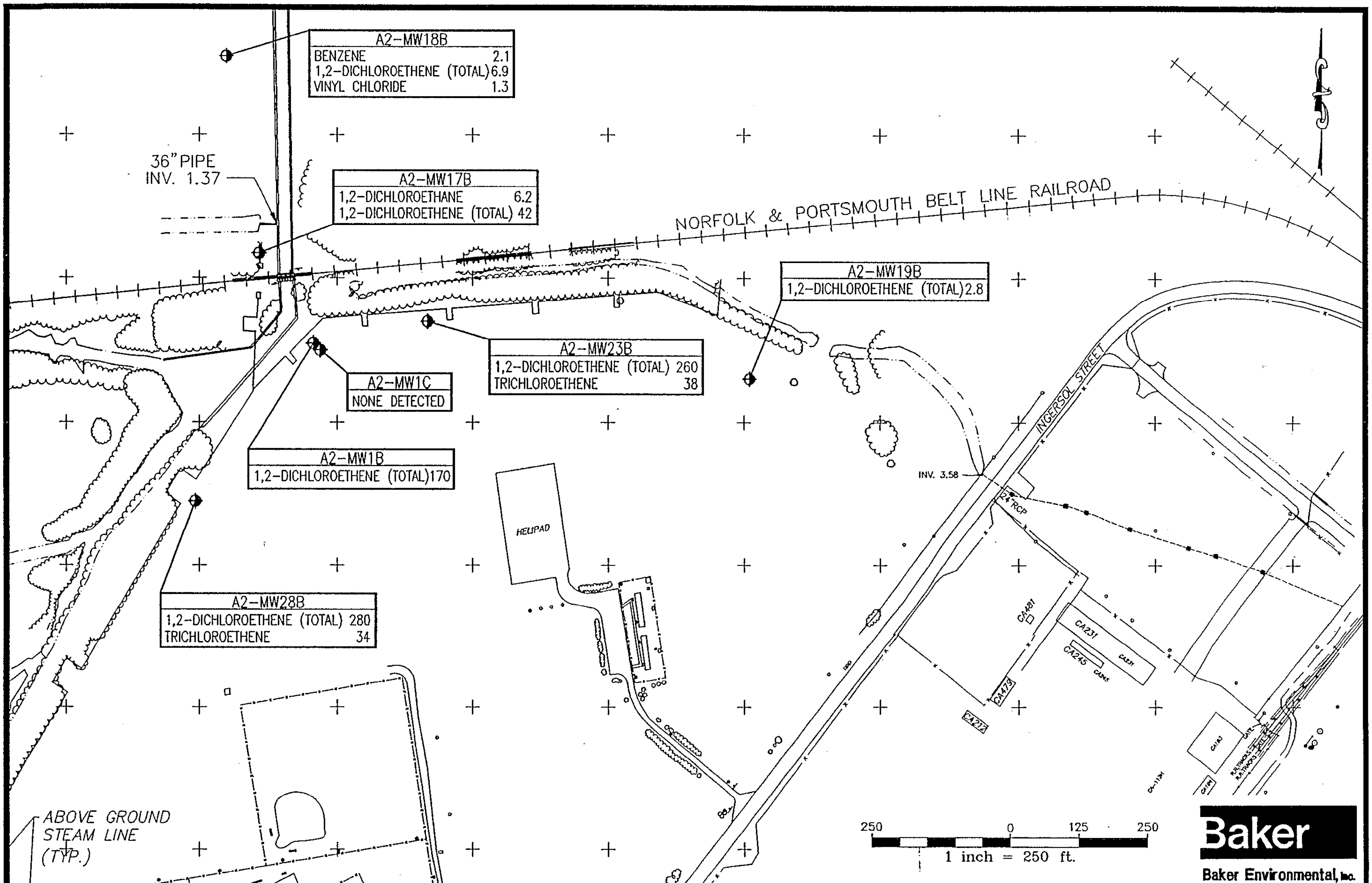
NOTE: ALL CONCENTRATIONS IN ug/L.

SOURCE: MILLER-STEPHENSON & ASSOC. JUNE 1992

FIGURE 5-3
AREA A2 SHALLOW GROUNDWATER
VOLATILES RESULTS
CAMP ALLEN LANDFILL

NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

084512FS



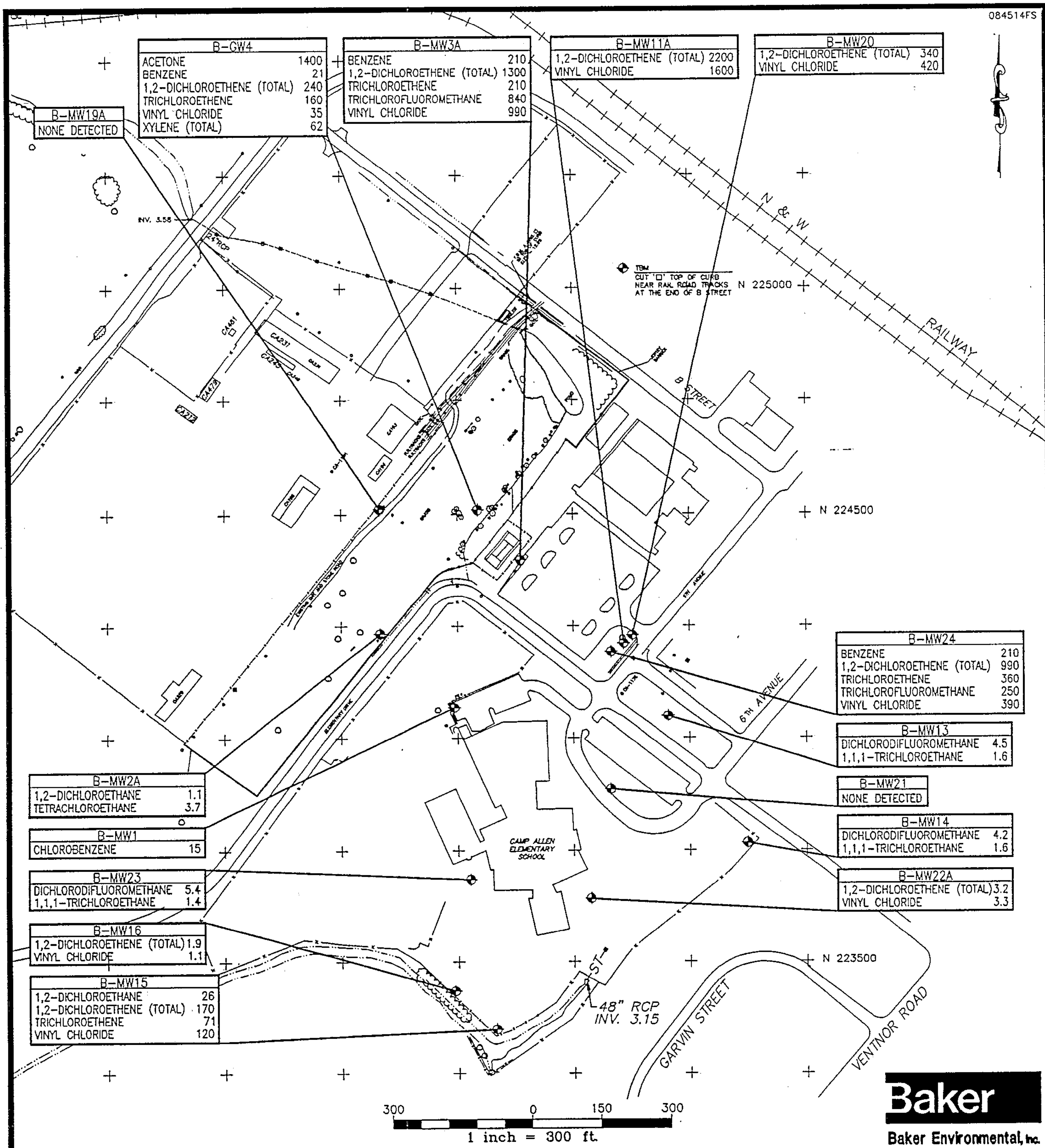
LEGEND

DEEP MONITORING WELL

NOTE: ALL CONCENTRATIONS IN ug/L.

SOURCE: MILLER-STEPHENSON & ASSOC. JUNE 1992

FIGURE 5-4
AREA A2 DEEP GROUNDWATER
VOLATILES RESULTS
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE
NORFOLK, VIRGINIA



LEGEND

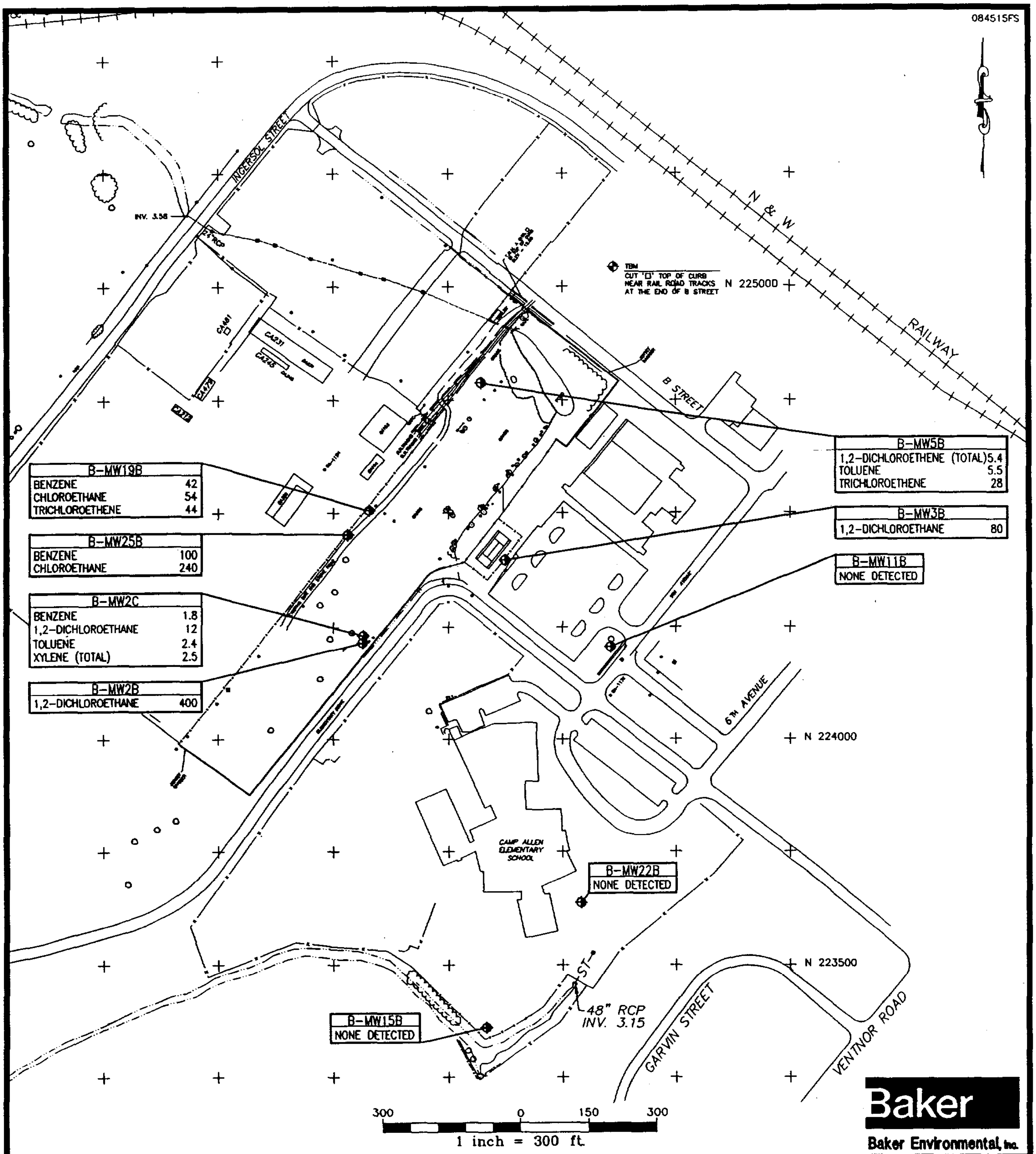
SHALLOW MONITORING WELL

NOTE: ALL CONCENTRATIONS IN ug/L.

SOURCE: MILLER-STEPHENSON & ASSOC. JUNE 1992

FIGURE 5-5
AREA B SHALLOW GROUNDWATER
VOLATILES RESULTS
CAMP ALLEN LANDFILL

NORFOLK NAVAL BASE
NORFOLK, VIRGINIA



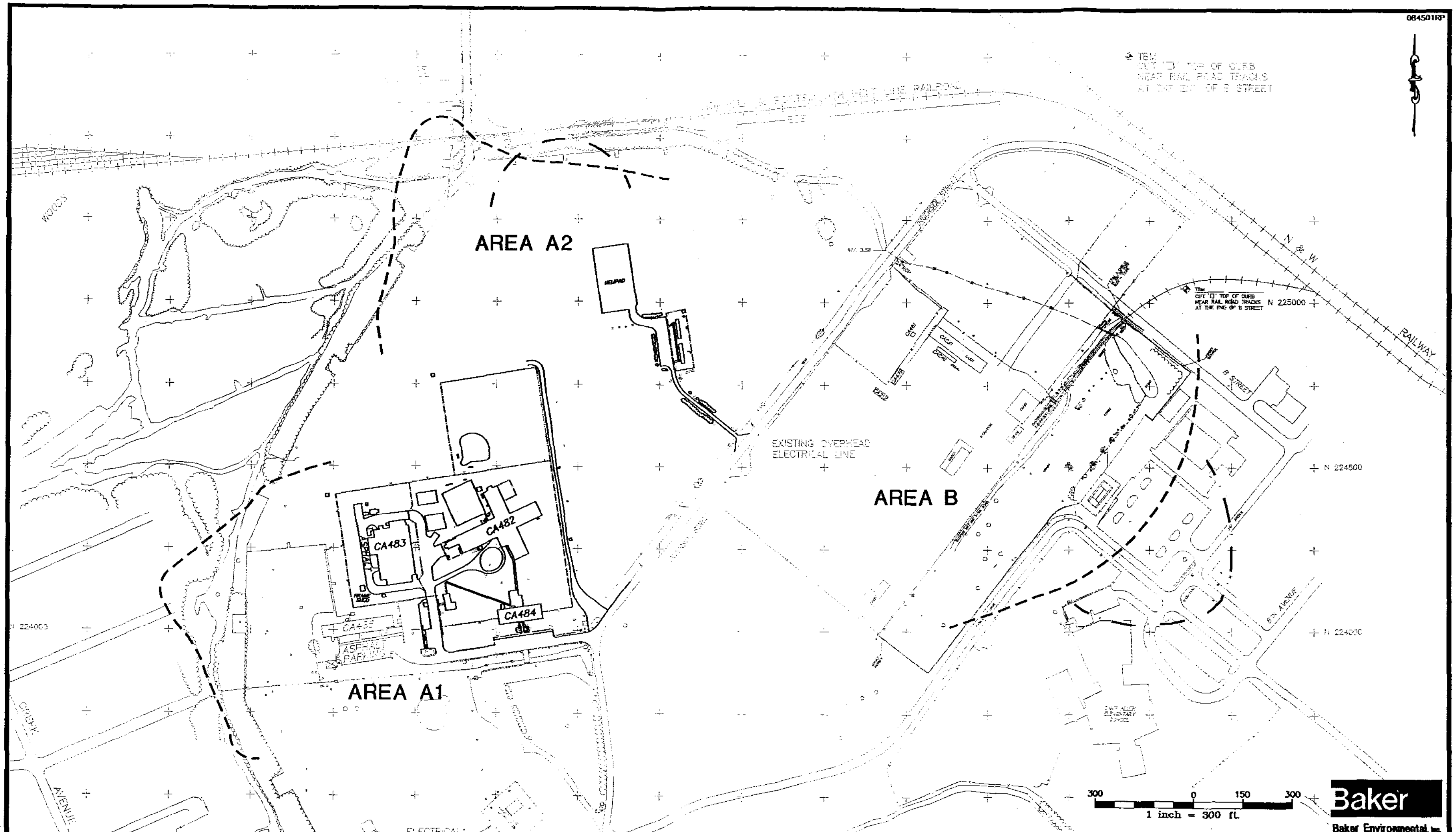
LEGEND

⊕ DEEP MONITORING WELL

NOTE: ALL CONCENTRATIONS IN ug/L.
SOURCE: MILLER-STEPHENSON & ASSOC. JUNE 1992

FIGURE 5-6
AREA B DEEP GROUNDWATER
VOLATILES RESULTS
CAMP ALLEN LANDFILL

NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

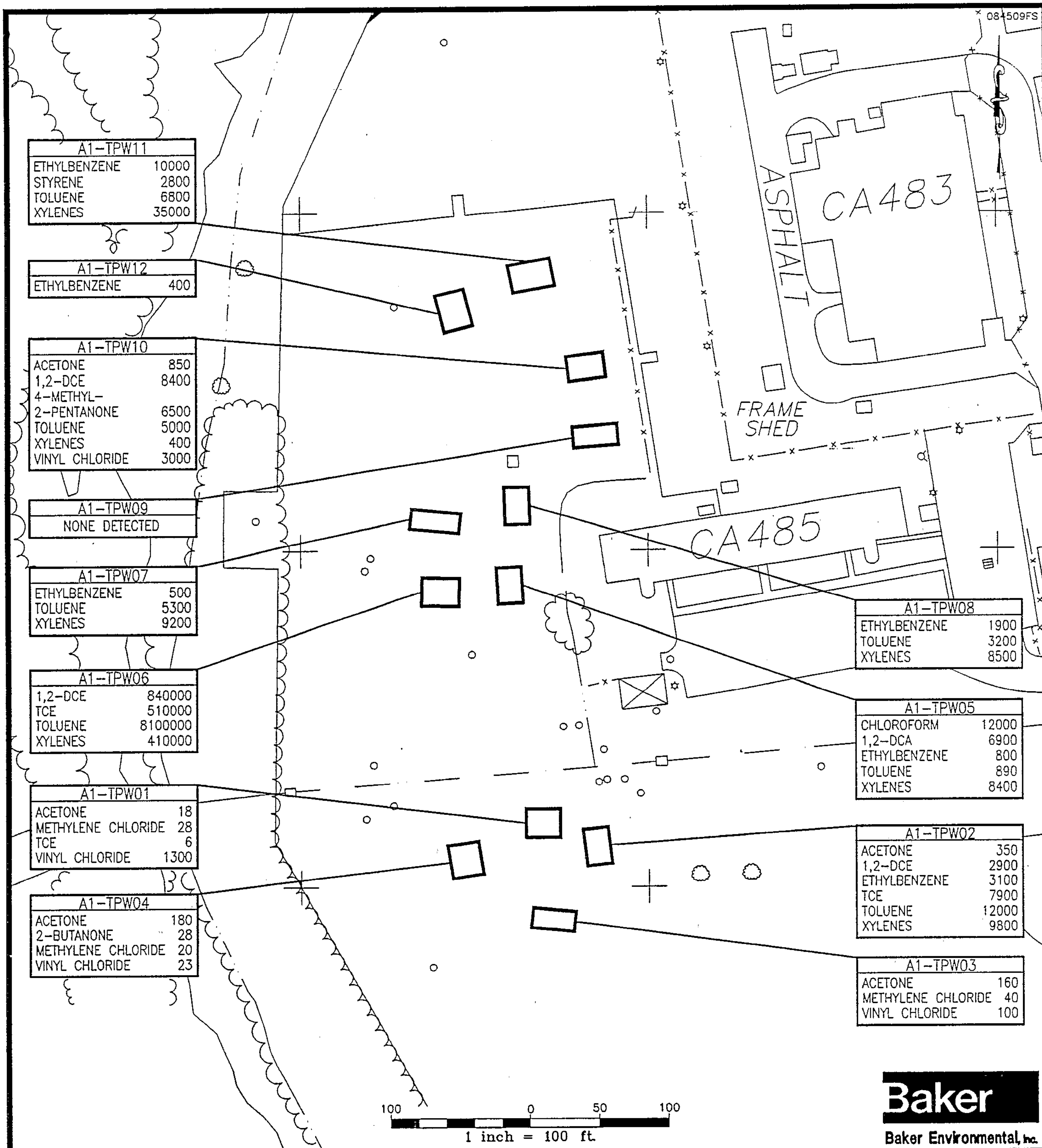


LEGEND

— · — DOWNGRADIENT EDGE OF PLUME – WATER TABLE AQUIFER

— — — DOWNGRADIENT EDGE OF PLUME – YORKTOWN AQUIFER

FIGURE 5-7
ESTIMATED DOWNGRADIENT EDGES
OF GROUNDWATER CONTAMINATION
CAMP ALLEN LANDFILL
NAVAL BASE NORFOLK
NORFOLK, VIRGINIA



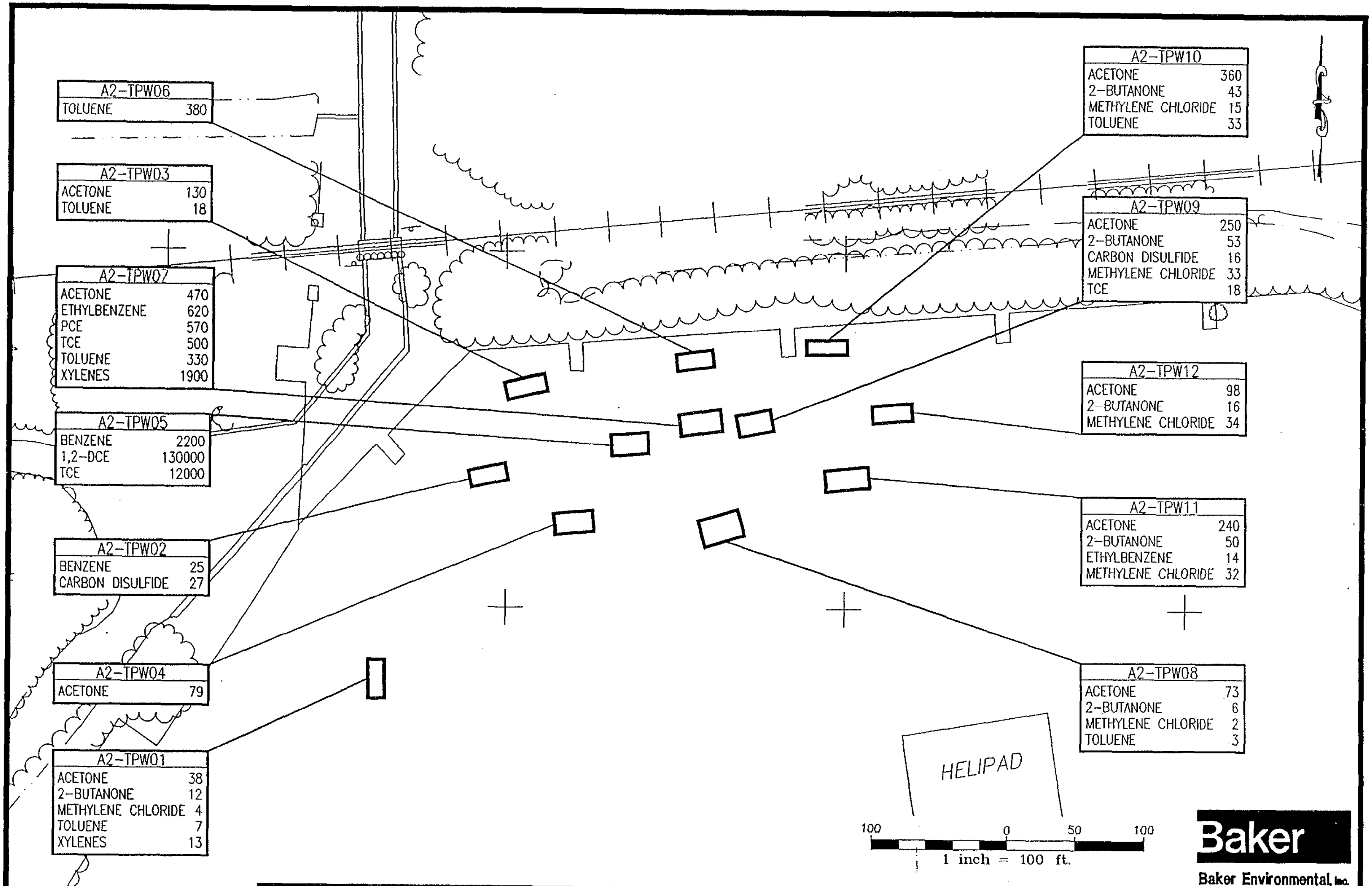
LEGEND

▭ TEST PIT

NOTE: ALL CONCENTRATIONS IN ug/kg.

FIGURE 5-8
AREA A1 TEST PIT LOCATIONS
AND VOLATILES RESULTS
CAMP ALLEN LANDFILL

NORFOLK NAVAL BASE
NORFOLK, VIRGINIA



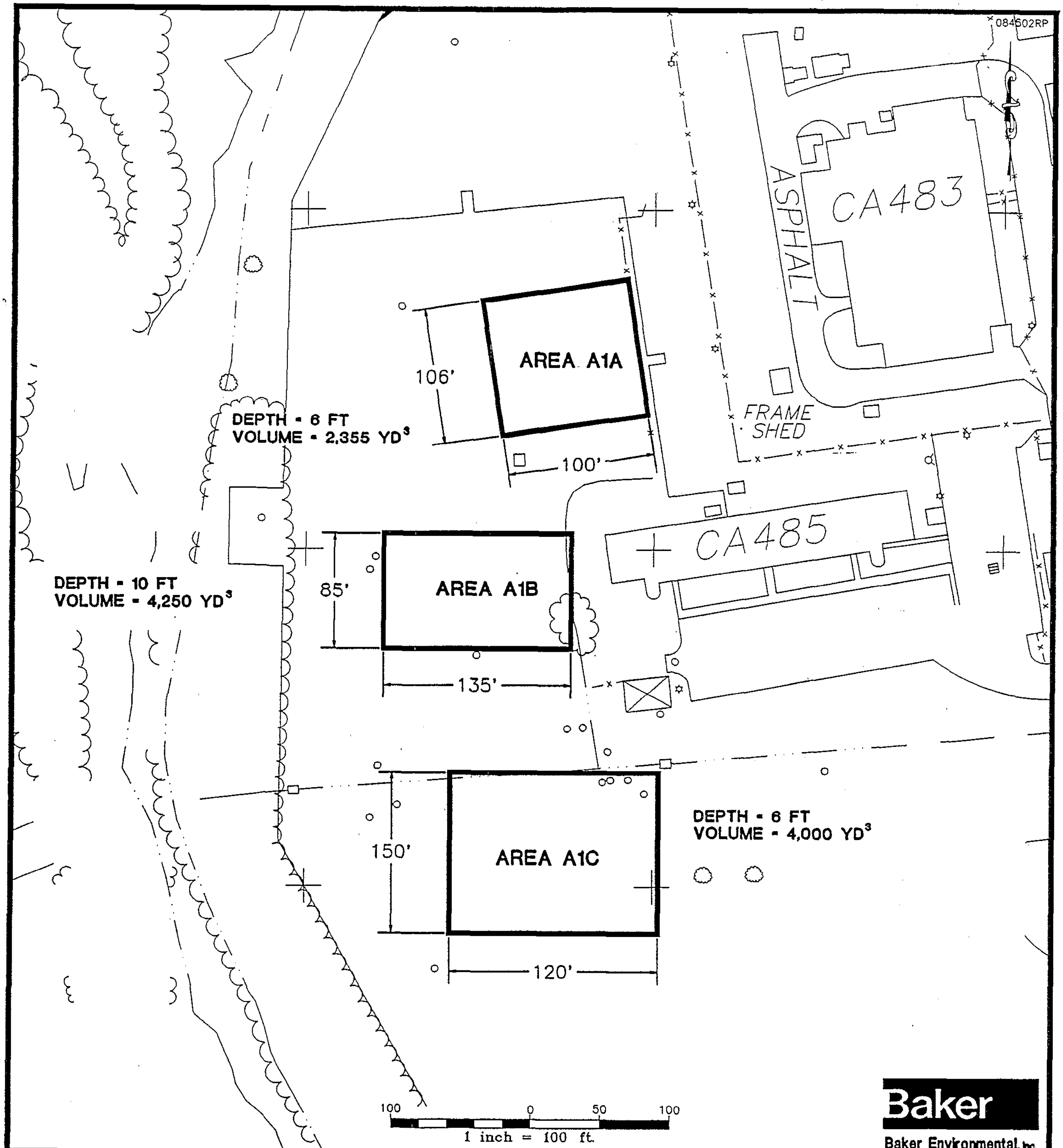
LEGEND

TEST PIT

NOTE: ALL CONCENTRATIONS IN ug/kg.

FIGURE 5-9
AREA A2 TEST PIT LOCATIONS
AND VOLATILES RESULTS
CAMP ALLEN LANDFILL
NORFOLK NAVAL BASE
NORFOLK, VIRGINIA

084508FS



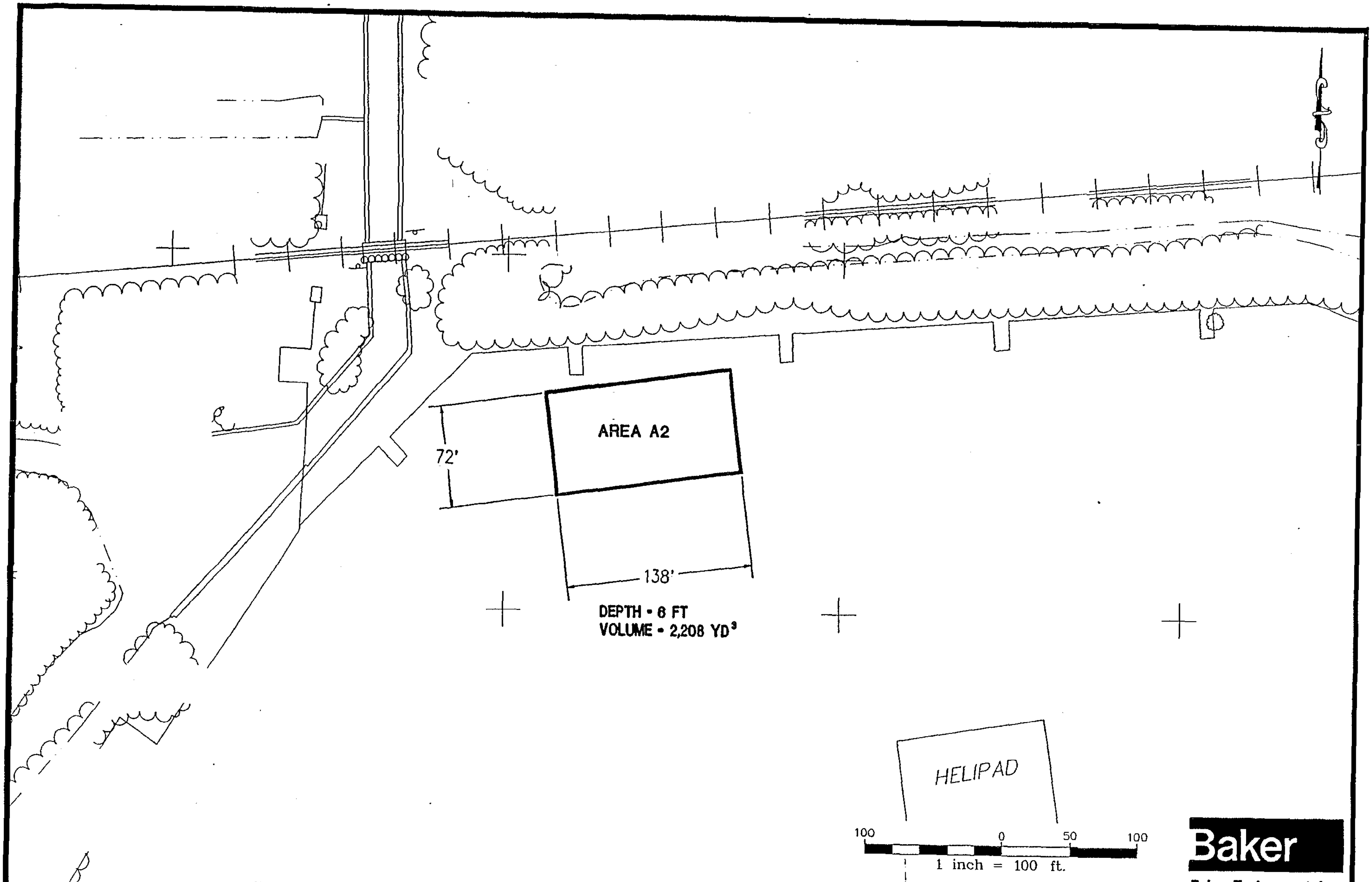
Baker
Baker Environmental, Inc.

LEGEND

BOUNDARY OF SOIL REMEDIATION AREA

FIGURE 5-10
AREA A1
ESTIMATED SOIL CONTAMINATION AREAS
CAMP ALLEN LANDFILL

NAVAL BASE NORFOLK
NORFOLK, VIRGINIA



LEGEND

BOUNDARY OF SOIL REMEDIATION AREA

FIGURE 5-11
AREA A2
ESTIMATED SOIL CONTAMINATION AREAS
CAMP ALLEN LANDFILL
NAVAL BASE NORFOLK
NORFOLK, VIRGINIA

084503RP

6.0 SUMMARY OF SITE RISKS

The potential human health risks associated with exposure to contaminated media within Areas A and B of the Camp Allen Landfill Site were evaluated under current use and potential future use scenarios in the baseline risk assessment. An ecological evaluation was also performed. The public health risks and ecological risks associated with the site are summarized below and are presented in detail in the Revised Final Baseline Risk Assessment (Baker, February, 1995).

6.1 Summary of Human Health Risks

The Human Health RA consisted of the following four components:

- Identification of Chemicals of Potential Concern
- Exposure Assessment
- Toxicity Assessment
- Risk Characterization

The results of these risk assessment components are summarized in the following sections.

6.1.1 Identification of Chemicals of Potential Concern

In the RI, chemicals detected in environmental media were discussed with respect to applicable Federal and Commonwealth of Virginia criteria and/or standards, and a preliminary account of chemicals of potential concern (COPCs) was presented. Chemicals detected in environmental media sampled during the RI were reevaluated to select COPCs for evaluation in the baseline RA. Chemicals selected as COPCs in the RA are presented in Tables 5-2 through 5-4 in Section 5.0 of this document.

COPC selection was based on the information provided in the USEPA Region III Technical Guidance on the Screening of Exposure Pathways and Selection of Contaminants of Concern, dated January 1993 (USEPA Region III, 1993) and USEPA's Risk Assessment Guidance for Superfund (RAGS), Volume I, Human Health Evaluation Manual (Part A), Interim Final, December 1989 (USEPA, 1989).

Both of these guidances provide a number of criteria by which chemical data can be evaluated. The primary criterion used in selecting a chemical as a COPC at the Camp Allen Landfill included comparison of maximum detected concentrations with USEPA Region III risk-based COPC screening concentrations, as derived in accordance with USEPA Region III Technical Guidance on the Screening of Exposure Pathways and Selection of Contaminants of Concern (USEPA Region III, January 1993), chemical prevalence, and site history.

6.1.2 Exposure Assessment

The exposure assessment addresses each current and future potential exposure pathway in groundwater, surface soil, surface water, sediment, and air. To determine whether human exposure could occur at the Camp Allen Landfill Site in the absence of remedial action, an exposure assessment was conducted as part of the RA, which identified potential exposure pathways and receptors. The following four elements were considered to determine whether a complete exposure pathway was present: a source and mechanism of chemical release; an environmental retention or transport medium; a point of potential human contact with the contaminated medium; and an exposure route (e.g., ingestion) at the contact point.

The exposure scenarios developed in the RA represent USEPA's Reasonable Maximum Exposure (RME). Relevant equations for assessing intakes and exposure factors were obtained from the Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation (RAGS) (USEPA, 1989), Exposure Factors Handbook (USEPA, 1989a), Dermal Exposure Assessment: Principles and Applications, Interim Report (USEPA, 1992), Superfund Exposure Assessment Manual (USEPA, 1988), and Standard Default Exposure Factors, Interim Final (USEPA, 1991).

Development of a conceptual site model of potential exposure is critical in evaluating all potential exposures for the aforementioned human receptors. The conceptual site model describes the area of concern in terms of suspected sources of contamination, the affected media, and all potential routes of migration of the contaminants present. Conceptual site models for Areas A and B are presented in Figures 6-1 and 6-2, respectively.

6.1.3 Toxicity Assessment

The potential health and environmental effects associated with potential exposure to the COPCs were identified during the toxicity assessment in the RA. The toxicological evaluation, which characterized the inherent toxicity of a compound, involved the review of scientific data to determine the nature and extent of the potential human health and environmental effects associated with potential exposure to the various chemicals. The end product of this evaluation was a collection of toxicological profiles for the COPCs. These toxicological profiles provided the qualitative weight-of-evidence (WOE) that demonstrated whether facility COPCs pose any actual or potential health and environmental effects.

An important component of the toxicity assessment process is the relationship between the dose of a compound (amount to which an individual or population is potentially exposed) and the potential for adverse health effects resulting from exposure to that dose. Dose-response relationships provide a means by which potential public health impacts may be evaluated. Standard reference doses and/or carcinogenic slope factors have been developed for many of the COPCs, which are provided in Table 6-1. Brief descriptions of these parameters are provided below.

Cancer slope factors (CSFs) have been developed by EPA's Carcinogenic Assessment Group for estimating excess lifetime cancer risks associated with exposure to potentially carcinogenic chemicals. CSFs, which are expressed in units of $(mg/kg\text{-}day)^{-1}$, are multiplied by the estimated intake of a potential carcinogen, in mg/kg-day, to provide an upper-bound estimate of the excess lifetime cancer risk associated with exposure at that intake level. The term "upper bound" reflects the conservative estimate of the risks calculated from the CSF. Use of this approach makes underestimation of the actual cancer risk highly unlikely. Cancer slope factors are derived from the results of human epidemiological studies or chronic animal bioassays to which animal-to-human extrapolation and uncertainty factors have been applied.

Reference doses (RfDs) have been developed by EPA for indicating the potential for adverse health effects from exposure to chemicals exhibiting noncarcinogenic effects. RfDs, which are expressed in units of mg/kg-day, are estimates of lifetime daily exposure levels for humans, including sensitive individuals. Estimated intakes of chemicals from environmental media (e.g., the amount of a chemical ingested from contaminated drinking water) can be compared to the RfD. RfDs are derived from human epidemiological studies or animal studies to which uncertainty factors have been applied (e.g., to account for the use of animal data to predict effects on humans). These uncertainty factors help ensure that the RfDs will not underestimate the potential for adverse noncarcinogenic effects to occur.

6.1.4 Risk Characterization Results

Incremental cancer risks (ICRs) and the potential to experience non-carcinogenic adverse effects (i.e., central nervous system effects, kidney effects, etc.), as measured by a hazard index (HI), were evaluated in this assessment. Estimated incremental cancer risks were compared to the target risk range of 10^{-4} to 10^{-6}, which the USEPA considers to be safe and protective of public health (USEPA, 1989). The calculated HI was compared to a threshold value of one; below this level, there is minimal potential to experience noncarcinogenic adverse health effects.

The risk assessment has shown that past practices at the Camp Allen Landfill Site have contaminated certain media to the extent that they pose a potential threat to human health only under certain potential future residential use scenarios. Although future residential use scenarios are unlikely at the site, they have been incorporated into the baseline comparisons. Table 6-2 summarizes potential health risk values associated with soil, surface water, sediment and air under current use and potential future use (residential) scenarios. Table 6-3 summarizes potential health risk values associated with groundwater under current use (nonpotable) and potential future use (residential) scenarios. Risk values presented for soil, sediment, surface water, air, shallow groundwater, and deep groundwater are considered to be "worst case," as they were derived by selecting those sampling locations with the most primary constituents of potential concern. Sample locations were also selected so as to not underestimate the resulting potential human health risks. Tables 6-4 and 6-5 present the total ICR and HI values for the current potential human receptors at Area A and Area B, respectively. Tables 6-6 and 6-7 present the total ICR and HI values for the future potential residential development of Area A and Area B, respectively.

A summary of human health risks for Areas A and B at the site, by media, is provided below.

Area A - Soil

Results of the baseline risk assessment indicate that no unacceptable adverse human health effects would be expected from exposure (via ingestion, inhalation, and dermal contact) to the surface soil at Area A under the current land use of the area as a Navy Brig (for either prisoners or Brig employees). Also, the risk assessment indicates that no unacceptable adverse human health effects would be expected from exposure to subsurface soils at Area A under a future use scenario for remedial construction workers. However, the HIs calculated for a child and an adult receptor under a future residential use scenario were 6.4 and 1.3, respectively, which exceed the acceptable HI of 1.0 under CERCLA. In addition, ICRs of 1.4×10^{-4} and 1.8×10^{-4} were estimated for a child and an adult receptor, respectively, under a future residential use scenario. These ICRs exceed USEPA's acceptable target risk range of 10^{-4} to 10^{-6}, which the USEPA considers to be safe and protective of public health. The chemicals found in Area A soil that contribute most predominantly to the risks are arsenic and cadmium.

Area B - Soil

Results of the baseline risk assessment indicate that no unacceptable adverse human health effects would be expected from exposure (via ingestion, inhalation, and dermal contact) to the surface soil at Area B under the current land use in the area (i.e., for either employees or children at the Camp Allen Elementary School). Also, the risk assessment indicates that no unacceptable adverse human health effects would be expected from exposure of remedial construction workers to subsurface soils at the Area B Landfill/Pond/School under a remediation (removal action) scenario. The HIs calculated for a child receptor under a future residential use scenario ranged from 1.6 at the Area B Landfill/Pond to 4.5 in the school area, which exceed the acceptable HI of 1.0; however, no unacceptable risks are indicated for an adult receptor under a future residential use scenario. Also, these risks were calculated at the Area B Landfill/Pond based on existing conditions prior to the removal action that has been implemented in this area. Therefore, the actual risks may be much lower in this area since the removal action has been successfully completed. The HI calculated for the Landfill/Pond area was mainly due to arsenic and cadmium in the soil, and the HI value for the Camp Allen Elementary School area was primarily the result of manganese in the soil.

Area A - Surface Water/Sediment

Results of the baseline risk assessment indicate that, under the current land use of this area as a Navy Brig, no unacceptable adverse human health effects would be expected from exposure (via ingestion and dermal contact) to surface water or sediment in Area A. Under a future residential land use scenario, the HIs calculated for a child receptor ranged from 4.0 to 4.8 for exposure (via ingestion and dermal contact) to shallow and deep sediments, respectively, which exceed the acceptable HI of 1.0. An ICR of 1.2×10^{-4} was estimated for a young child resident exposed to shallow sediments, which exceeds the target risk range of 10^{-4} to 10^{-6}. However, no unacceptable risks are indicated for an adult receptor for exposure to sediments under a future residential use scenario. Also, under a future residential land use scenario, the ICR for a child receptor associated with exposure (via ingestion and dermal contact) to surface water is 2.0×10^{-4}, which slightly exceeds the acceptable ICR of 1.0×10^{-4}. Under a future residential land use scenario, the ICR for an adult receptor associated with exposure (via ingestion and dermal contact) to surface water is 1.2×10^{-4}, which also slightly exceeds the acceptable ICR of 1.0×10^{-4}. The chemicals found in Area A sediment that contribute most predominantly to the risks are arsenic, Aroclor-1254, and Aroclor-1260. The chemical found in Area A surface water that contributes most predominantly to the risks is Aroclor-1254.

Area B - Surface Water/Sediment

Results of the baseline risk assessment indicate that, under the current land use of the Area B pond and school, no unacceptable human health effects would be expected from exposure (via ingestion and dermal contact) to the surface water and sediment in the vicinity of Area B. Under a future residential land use scenario, the HI calculated for a child receptor at the Area B Landfill and Pond, under a future residential scenario, was 2.0 for exposure (via ingestion and dermal contact) to shallow sediments. This exceeds the acceptable HI of 1.0. However, no unacceptable risks are indicated for a child receptor for exposure to surface water, and no unacceptable risks are indicated for an adult receptor for exposure to surface water or sediments under a future residential use scenario. The chemicals found in Area B sediment that contribute most predominantly to the risks are arsenic and cadmium.

Areas A and B - Indoor/Outdoor Air

As shown in Table 6-2, results of the baseline risk assessment indicate that, under the current use of Area A (i.e., employees and prisoners at the Navy Brig), no unacceptable human health effects would be expected from the indoor air exposure pathway. Similarly, under the current use exposure scenario for Area B (i.e., children attending Camp Allen Elementary School), no unacceptable human health effects would be expected from exposure to indoor air. With respect to exposure to outdoor (ambient) air, no unacceptable human health effects would be expected for both adult and child receptors under both current and future residential use scenarios.

Area A Groundwater

Results of the baseline risk assessment for Area A indicate that no unacceptable adverse human health effects would be expected from exposure (via incidental ingestion and dermal contact) to the shallow groundwater under the current land use in the area (i.e., nonpotable use of groundwater by Glenwood Park residents). Groundwater currently is not used for any purpose at the Navy Brig facility in Area A.

Under a potential future residential use scenario, the baseline risk assessment indicates that unacceptable risks for both children and adult receptors would be expected from exposures to COPCs in both the shallow and deep aquifers via ingestion, dermal contact, and inhalation under a potable use scenario. A summary of maximum incremental cancer risks and hazard indices for shallow (water table aquifer) and deep (Yorktown Aquifer) groundwater under potential current and future use scenarios is presented in Table 6-3. The chemicals found in Area A groundwater that contribute most predominantly to the risks are 1,2-dichloroethene, vinyl chloride, and trichloroethene.

Area B Groundwater

Results of the baseline risk assessment for Area B indicate that no unacceptable adverse human health effects would be expected from exposure to either deep or shallow groundwater under the current land use in the area since groundwater currently is not used for any purpose at Area B.

Under a potential future residential use scenario (potable use of shallow or deep groundwater), the baseline risk assessment indicates that unacceptable risks for both children and adult receptors would be expected from exposure via ingestion, dermal contact, and inhalation . A summary of maximum incremental cancer risks and hazard indices for shallow and deep groundwater under potential current and future use scenarios is presented in Table 6-3. The chemicals found in Area B groundwater that contribute most predominantly to the risks are 1,2-dichloroethene, benzene, vinyl chloride, trichloroethene, and arsenic.

6.2 Summary of Ecological Risks

The ecological evaluation focused upon three measures of environmental impact from the Camp Allen Landfill: exceedances of state and federal criteria for surface waters and sediments; the presence and distribution of benthic macroinvertebrates; and a qualitative assessment of terrestrial flora and fauna.

Surface water constituents exceeded federal criteria and/or Commonwealth of Virginia standards at sampled locations throughout Areas A and B. National Oceanic and Atmospheric Administration (NOAA) sediment criteria were also exceeded at various locations. These exceedances represent the potential for environmental impacts.

The endpoint of the ecological evaluation used to assess the aquatic and terrestrial environment is decreased integrity of the aquatic and terrestrial community. Exceedances of surface water and sediment quality measurement endpoints indicate a low to moderate potential for risk to aquatic life. The benthic community is characteristic of an aquatic ecosystem that has potential impacts from both contaminant exposure and natural conditions. In addition, this benthic community exhibited spatial variations within the range of natural population variation in similar environments. Based on this finite ecological risk assessment, the aquatic community may be impacted by releases from the Camp Allen Landfill. However, remedial measures are being implemented that provide both source removal and source containment, as well as treatment to control further contaminant migration into the drainage ditches. Therefore, post-remediation studies are warranted to evaluate the reduction of risks to the aquatic community as a result of site remediation activities.

The post-remediation ecological monitoring program will include: 1) surface water and sediment sampling along the drainage ditches adjacent to the Area A and B Landfills and at the Bousch Creek outfall on Willoughby Bay; 2) data analysis; 3) revisions to the Ecological Risk Assessment, as required; and, 4) development of a regional environmental perspective including point and non-point sources to the Bousch Creek and Willoughby Bay watersheds.

The terrestrial qualitative evaluation did not produce any significant indicators of risk to terrestrial receptors based on observations of diversity and productivity of the fauna and flora. Significant potential effects on terrestrial receptors resulting from Area A and B were not observed at any location. For an urban area, the terrestrial habitats appeared to be diverse and productive.

6.2.1 Threatened and Endangered Species

One endangered bird, the peregrine falcon (Falco peregrinus), had been observed at the Camp Allen Landfill during the RI field sampling effort. The falcon does not nest in the area and has been seen infrequently. Local ecologists believe that it was attracted to the site to feed on flocks of starlings and pigeons at the salvage yard.

Incomplete information is available on the levels of environmental contamination at the site (i.e., contaminant levels in site plants and animals), on bioaccumulation and bioavailability of contaminants, and on specific contaminant effects to peregrine falcons. Therefore, it is not possible to definitively assess risk to the falcons. However, the falcons are not present at the site regularly and the birds on which they do feed appear to be healthy.

SECTION 6.0 TABLES

TABLE 6-1

TOXICITY FACTORS
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Constituents	Oral CSF (mg/kg/day)$^{-1}$	Inhal. CSF (mg/kg/day)$^{-1}$	Oral RfD (mg/kg/day)	Inhal. RfD (mg/kg/day)	WOE	Target	Critical Effect
Volatile Organic Compounds: benzene	2.90E-02 (i)	2.90E-02 (i)	--	1.71E-03 (e)	A	Blood	Hematological impairment
benzyl chloride	1.70E-01 (i)	--	--	--	B2	--	--
bromomethane	--	--	1.40E-03 (i)	1.43E-03 (i)	D	Cells	Epithelial hyperplasia of the forestomach/nasal cavity
2-butanone	--	--	6.00E-01 (i)	2.86E-01 (i)	D	Fetus	Decreased birth rate
chlorobenzene	--	--	2.00E-02 (i)	5.71E-03 (a)	D	Liver	Histopathologic changes in liver
chloroform	6.10E-03 (i)	8.05E-02 (i)	1.00E-02 (i)	--	B2	Liver	Lesions
chloromethane	1.30E-02 (h)	6.30E-03 (h)	--	--	C	--	--
1,4-dichlorobenzene	2.40E-02 (h)	--	--	2.29E-01 (i)	C	Liver	Increased weight
1,1-dichloroethane	--	--	1.00E-01 (h)	1.43E-01 (a)	C	--	None observed
1,2-dichloroethane	9.10E-02 (i)	9.10E-02 (i)	--	2.86E-03 (e)	B2	--	--
1,1-dichloroethene	6.00E-01 (i)	1.75E-01 (i)	9.00E-03 (i)	--	C	Liver	Lesions
1,2-dichloroethene	--	--	9.00E-03 (h)	--	D	Liver	Lesions
4-methyl-2-pentanone (methyl isobutyl ketone)	--	--	8.00E-02 (h)	2.29E-02 (a)	--	Liver and Kidney	Increased weight
methylene chloride	7.50E-03 (i)	1.64E-03 (i)	6.00E-02 (i)	8.57E-01 (h)	B2	Liver	Liver toxicity

TABLE 6-1 (Continued)

TOXICITY FACTORS
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Constituents	Oral CSF $(mg/kg/day)^{-1}$	Inhal. CSF $(mg/kg/day)^{-1}$	Oral RfD (mg/kg/day)	Inhal. RfD (mg/kg/day)	WOE	Target	Critical Effect
tetrachloroethene	5.20E-02 (e)	2.03E-03 (e)	1.00E-02 (i)	--	B2/C[(1)]	Liver	Hepatotoxicity
toluene	--	--	2.00E-01 (i)	1.14E-01 (i)	D	Liver and Kidney	Altered weight
~~1,1,1-trichloroethane~~	--	--	~~9.00E-02~~ (w)	~~2.86E-01~~ (w)	~~D~~	~~CNS/Whole Body~~	~~Hyperactivity/decreased weight~~
trichloroethene	1.10E-02 (w)	6.00E-03 (e)	6.00E-03 (e)	--	B2	--	--
1,2,4-trimethylbenzene	--	--	5.40E-04 (e)	--	--	--	--
1,3,5-trimethylbenzene	--	--	4.00E-04 (e)	--	--	--	--
vinyl chloride	1.90 (h)	3.00E-01 (h)	--	--	A	--	--
m-xylene	--	--	2.00 (h)	2.00E-01 (w)	D	CNS/Whole Body	Hyperactivity/decreased weight
o-xylene	--	--	2.00 (h)	2.00E-01 (w)	D	CNS/Whole Body	Hyperactivity/decreased weight
p-xylene	--	--	--	8.57E-02 (w)	D	CNS/Whole Body	Hyperactivity/decreased weight
xylenes (total)	--	--	2.00 (i)	--	D	CNS/Whole Body	Hyperactivity/decreased weight

TABLE 6-1 (Continued)

TOXICITY FACTORS
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Constituents	Oral CSF (mg/kg/day)$^{-1}$	Inhal. CSF (mg/kg/day)$^{-1}$	Oral RfD (mg/kg/day)	Inhal. RfD (mg/kg/day)	WOE	Target	Critical Effect
Semivolatile Organic Compounds:							
acenaphthene	--	--	6.00E-02 (i)	--	--	Liver	Hepatotoxicity
bis(2-chloroethyl)ether	1.10 (i)	1.16 (i)	--	--	B2	--	--
bis(2-ethylhexyl)phthalate	1.40E-02 (i)	--	2.00E-02 (i)	--	B2	Liver	Increased weight
2,4-dimethylphenol	--	--	2.00E-02 (i)	--	--	CNS/Blood	Clinical signs/ hematological changes
hexachlorobutadiene	7.80E-02 (i)	7.70E-02 (i)	2.00E-04 (h)	--	C	Renal tubules (kidney)	Regeneration (increased weight)
2-methylphenol (o-cresol)	--	--	5.00E-02 (i)	--	C	Whole Body/CNS	Decreased body weight and neurotoxicity
4-methylphenol (p-cresol)	--	--	5.00E-03 (h)	--	C	Whole Body/ Respiratory Sys./ CNS	Maternal death/distress/ hyperactivity
Pesticides:							
aldrin	17.0 (i)	17.1 (i)	3.00E-05 (i)	--	B2	Liver	Liver toxicity
beta-BHC	1.80 (i)	1.79 (i)	--	--	C	--	--
gamma-BHC (Lindane)	1.30 (h)	--	3.00E-04 (i)	--	C	Liver and Kidney	Liver and kidney toxicity
alpha-chlordane[(2)]	1.30 (i)	1.29 (i)	6.00E-05 (i)	--	B2	Liver	Regional liver hypertrophy
4,4'-DDD	2.40E-01 (i)	--	--	--	B2	--	--

TABLE 6-1 (Continued)

TOXICITY FACTORS
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Constituents	Oral CSF $(mg/kg/day)^{-1}$	Inhal. CSF $(mg/kg/day)^{-1}$	Oral RfD (mg/kg/day)	Inhal. RfD (mg/kg/day)	WOE	Target	Critical Effect
4,4'-DDE	3.40E-01 (i)	--	--	--	B2	--	--
4,4'-DDT	3.40E-01 (i)	3.40E-01 (i)	5.00E-04 (i)	--	B2	Liver	Lesions
dieldrin	16.0 (i)	16.1 (i)	5.00E-05 (i)	--	B2	Liver	Lesions
heptachlor epoxide	9.10 (i)	9.10 (i)	1.30E-05 (i)	--	B2	Liver	Increased weight
PCBs: Aroclor-1254[3]	7.70 (i)	--	--	--	B2	--	--
Aroclor-1260[3]	7.70 (i)	--	--	--	B2	--	--
Inorganics: aluminum	--	--	1.00E+00 (o)	--	--	--	--
antimony	--	--	4.00E-04 (i)	--	D	Whole Body/Blood	Increased mortality/ altered chemistry
arsenic	1.75 (i)	15.1 (i)	3.00E-04 (i)	--	A	Skin	Keratosis/hyperpigmentation
barium	--	--	7.00E-02 (i)	1.43E-04 (a)	D	Cardiovascular system	Increased blood pressure
beryllium	4.30 (i)	8.40 (i)	5.00E-03 (i)	--	B2	--	None observed
cadmium	--	6.30 (i)	5.00E-04 (i)	--	B1	Renal cortex	Significant proteinuria
chromium	--	42.0 (i)	5.00E-03 (i)	--	A	--	None observed

TABLE 6-1 (Continued)

TOXICITY FACTORS
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Constituents	Oral CSF $(mg/kg/day)^{-1}$	Inhal. CSF $(mg/kg/day)^{-1}$	Oral RfD (mg/kg/day)	Inhal. RfD (mg/kg/day)	WOE	Target	Critical Effect
copper	--	--	3.71E-02 (h)	--	D	Gastrointestinal system	Irritation
lead	--	--	--	--	B2	--	--
manganese	--	--	5.00E-03 (i)	1.43E-05 (i)	D	CNS/lung	Effects
mercury (inorganic)	--	--	3.00E-04 (h)	8.57E-05 (h)	D	Kidney/ nervous system	Effects/neurotoxicity
nickel (refinery dusts)	--	8.40E-01 (i)	--	--	A	--	--
nickel (soluble salts)	--	--	2.00E-02 (i)	--	C	Whole body	Decreased body and organ weights
silver	--	--	5.00E-03 (i)	--	D	Skin	Argyria
thallium(4)	--	--	8.00E-05 (i)	--	D	Liver/Blood/Hair	Increased SGOT/Increased Serum LDH/Adopecia
vanadium	--	--	7.00E-03 (h)	--	D	--	--
zinc	--	--	3.00E-01 (i)	--	D	Blood	Decreased blood enzyme

Notes: (1) Under review
(2) Toxicity factors for chlordane used.
(3) Toxicity factor for polychlorinated biphenyls.
(4) Reference dose applies to thallium carbonate, chloride or sulfate.
i = Integrated Risk Information System (IRIS), 1994
e = Environmental Criteria and Assessment Office (ECAO) (as cited from 4th quarter USEPA, Region III RBC Tables)
h = Health Effects Assessment Summary Tables (HEAST), 1994
a = EAST Alternative Method, 1994
w = withdrawn from IRIS or HEAST
o = Other EPA Document (as cited from 4th quarter USEPA, Region III RBC tables)

CSF = cancer slope factor
RfD = reference dose
WOE = weight-of-evidence

USEPA WOE Classifications:
A = Carcinogen
B = Probable Carcinogen
C = Possible Carcinogen
D = not classified

TABLE 6-2

SUMMARY TABLE OF MAXIMUM INCREMENTAL CANCER RISKS (ICR) AND HAZARD INDICES (HI) FOR MEDIA OF INTEREST, AREAS A AND B CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

	Area A				Area B - Pond/Landfill				Area B - School			
	Potential Current		Potential Future		Potential Current		Potential Future		Potential Current		Potential Future	
Medium	HI	ICR	HI[3]	ICR[3]	HI[1]	ICR[1]	HI[3]	ICR[3]	HI	ICR	HI[3]	ICR
Soils	0.82[2]	7.0×10^{-5}[1]	**6.4**	**1.8×10^{-4}[6]**	0.13	1.9×10^{-5}	**1.6**	4.5×10^{-5}[6]	0.73[5]	2.7×10^{-5}[1]	**4.5**	6.7×10^{-5}[6]
Sediments	0.38[4]	1.8×10^{-5}[4]	**4.0**	1.2×10^{-4}[3]	0.002	4.4×10^{-6}	**2.0**	7.1×10^{-5}[3]	[7]	[7]	0.014	[7]
Surface Waters	0.040[4]	4.2×10^{-5}[4]	0.64	**2.0×10^{-4}[3]**	0.074	2.1×10^{-6}	0.34	2.1×10^{-5}[3]	0.019[5]	3.1×10^{-6}[5]	0.03	6.3×10^{-6}[3]
Indoor Air	0.25[2]	1.3×10^{-6}[1]	NA	NA	NA	NA	NA	NA	0.094[5]	3.4×10^{-7}[5]	NA	NA
Outdor (Ambient) Air	0.60[1]	1.3×10^{-6}[1]	0.052[3]	1.2×10^{-7}[3]	0.13[1]	1.3×10^{-6}[1]	0.052[3]	1.2×10^{-7}[3]	0.021[5]	4.9×10^{-8}[5]	0.052[3]	1.2×10^{-7}[3]

Notes: Hazard indices exceeding 1 and Incremental Cancer Risks exceeding 1×10^{-4} are shown in bold face type.

[1] Industrial Use (Adults)
[2] Brig Prisoners
[3] Resident Young Child (1-6 yrs)
[4] Resident Older Child (6-15 yrs)
[5] School Children (6-12 yrs)
[6] Resident Adults.
[7] No contaminants of concern detected.
NA - Not applicable

Current - Current potential exposure
Future - Future potential (residential) exposure

TABLE 6-3

SUMMARY TABLE OF MAXIMUM INCREMENTAL CANCER RISKS (ICR) AND HAZARD INDICES (HI) FOR SHALLOW AND DEEP GROUNDWATER, AREAS A AND B CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

	Area A (and Glenwood Park Residential Area)							
	Potential Current				Potential Future			
	Child		Adult		Child		Adult	
Medium	HI	ICR	HI	ICR	HI	ICR	HI	ICR
Shallow	0.003	3.8×10^{-7}	0.001	6.4×10^{-7}	**620**	**1.8×10^{-1}**	**300**	**2.7×10^{-1}**
Deep Groundwater	NA	NA	NA	NA	**12**	**5.4×10^{-3}**	**7.5**	**8.9×10^{-3}**

	Area B							
	Potential Current				Potential Future			
	Child		Adult		Child		Adult	
Medium	HI	ICR	HI	ICR	HI	ICR	HI	ICR
Shallow	NA	NA	NA	NA	**30**	**1.4×10^{-2}**	**0.19**	**2.9×10^{-2}**
Deep Groundwater	NA	NA	NA	NA	**4.6**	3.8×10^{-5}	**2.8**	8.0×10^{-5}

Notes: Hazard indices exceeding 1 and Incremental Cancer Risks exceeding 1×10^{-4} are shown in bold face type.
Current Use - Potential nonpotable use of groundwater (child, swimming pools; adults, car washing).
Future Use - Potential residential potable use of groundwater.
NA - Scenario not applicable (i.e., groundwater in Area B currently not used for potable or nonpotable).

TABLE 6-4

TOTAL SITE ICR AND HI VALUES FOR CURRENT POTENTIAL HUMAN RECEPTORS, AREA A CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Receptors	Total HI	Total ILCR
Local Adults(1)	5.9×10^{-02}	3.4×10^{-05}
Local Children(2)*	4.5×10^{-01}	6.0×10^{-05}
Brig Employees(3)	$1.3 \times 10^{+00}$	1.1×10^{-04}
Brig Prisoners(4)	$1.1 \times 10^{+00}$	8.1×10^{-06}

Notes: (1) Local adults could potentially be exposed to COPCs by dermal contact and accidental ingestion of shallow groundwater, surface waters, and sediments, as well as inhalation of VOCs in outdoor air.

(2) Local children could potentially be exposed to surface waters, sediments, and shallow-groundwaters, as well as inhalation of VOCs in outdoor air. Total site risk values represent potential exposure to surface waters and sediments by older children and total site risk values for younger children potentially exposed to COPCs in residential area shallow groundwater.

(3) Brig employees (civilian) could potentially be exposed to COPCs by dermal contact and accidental ingestion of soils, surface waters, and sediments, as well as the inhalation of VOCs detected in indoor and outdoor air and fugitive dusts.

(4) Brig prisoners could potentially be exposed to COPCs through dermal contact and accidental ingestion of soils, as well as inhalation of VOCs detected in indoor and outdoor air. Prisoners do not generally gain access to the ditches.

* Total HI and ICR values derived by summing the HI and ICR values for younger children (ages 1 to 6 years) and older children (ages 7 to 15 years) potentially exposed to Area A ditch surface waters and sediments.

TABLE 6-5

TOTAL SITE ICR AND HI VALUES FOR CURRENT POTENTIAL HUMAN RECEPTORS, AREA B CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Receptors	Total HI	Total ILCR
Adult Workers(1)	2.9×10^{-01}	2.7×10^{-05}
Elementary School Children(2)	8.6×10^{-01}	1.5×10^{-05}
Elementary School Workers(3)	4.4×10^{-01}	2.9×10^{-05}

Notes: (1) Adult workers (employees and prisoners) could potentially be exposed to COPCs by dermal contact and accidental ingestion of soils, surface waters, and sediments, as well as inhalation of fugitive dusts and VOCs in outdoor air, in Area B Pond during maintenance activities.

(2) Elementary school children (6 to 12) could potentially be exposed to COPCs by dermal contact and accidental ingestion of soils, surface water, and sediments, as well as the inhalation of fugitive dusts and VOCs in outdoor air, in Area B School.

(3) Elementary school workers could potentially be exposed to COPCs by dermal contact and accidental ingestion of soils, surface waters, and sediments, as well as the inhalation of fugitive dusts and VOCs in outdoor air, in Area B School.

TABLE 6-6

TOTAL SITE ICR AND HI VALUES FOR FUTURE POTENTIAL HUMAN RECEPTORS, AREA A* CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Receptors	Total HI	Total ILCR
Resident Adults[1]	$3.0 \times 10^{+02}$ ($2.9 \times 10^{+02}$)	2.7×10^{-01} (2.7×10^{-01})
Resident Children[2]	$6.4 \times 10^{+02}$ ($6.3 \times 10^{+02}$)	1.8×10^{-01} (1.8×10^{-01})
Construction Workers[3]	8.0×10^{-02}	1.3×10^{-06}

Notes: Values in parentheses represent risk values derived using dissolved inorganic constituent results for groundwaters.

(1) Future resident adults could potentially be exposed to COPCs by dermal contact and accidental ingestion of soils, surface waters, and sediments, as well as inhalation of VOCs detected in outdoor air. Potable use of shallow and deep groundwaters were also evaluated. Potential exposure pathways included ingestion, whole body dermal contact, and inhalation of VOCs while showering.

(2) Future resident children could potentially be exposed to COPCs by dermal contact and accidental ingestion of soils, surface waters, and sediments, as well as inhalation of VOCs detected in outdoor air, and by the potable use of shallow and deep groundwaters.

(3) Construction workers could potentially be exposed to COPCs by dermal contact and accidental ingestion of subsurface soils, and the inhalation of fugitive dusts emanating from excavated subsurface soils.

* Total site ICR and HI values presented using shallow well location B-20W since this location was associated with the most elevated risks in Area A.

TABLE 6-7

TOTAL SITE ICR AND HI VALUES FOR FUTURE POTENTIAL HUMAN RECEPTORS, AREA B*
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Receptors	Total HI	Total ILCR
Resident Adults[(1)]	$2.0 \times 10^{+01}$ ($1.1 \times 10^{+01}$)	2.9×10^{-02} (2.8×10^{-02})
Resident Children[(2)]	$3.5 \times 10^{+01}$ ($2.2 \times 10^{+01}$)	1.4×10^{-02} (1.4×10^{-02})
Construction Workers[(3)]	7.5×10^{-01}	7.2×10^{-06}

Notes: Values in parentheses represent risk values derived using dissolved inorganic constituent results for groundwaters.

(1) Future resident adults could potentially be exposed to COPCs by dermal contact and accidental ingestion of soils, surface waters, and sediments, as well as inhalation of fugitive dusts and VOCs detected in outdoor air. Potable use of shallow and deep groundwaters were also evaluated. Potential exposure pathways included ingestion, whole body dermal contact, and inhalation of VOCs while showering.

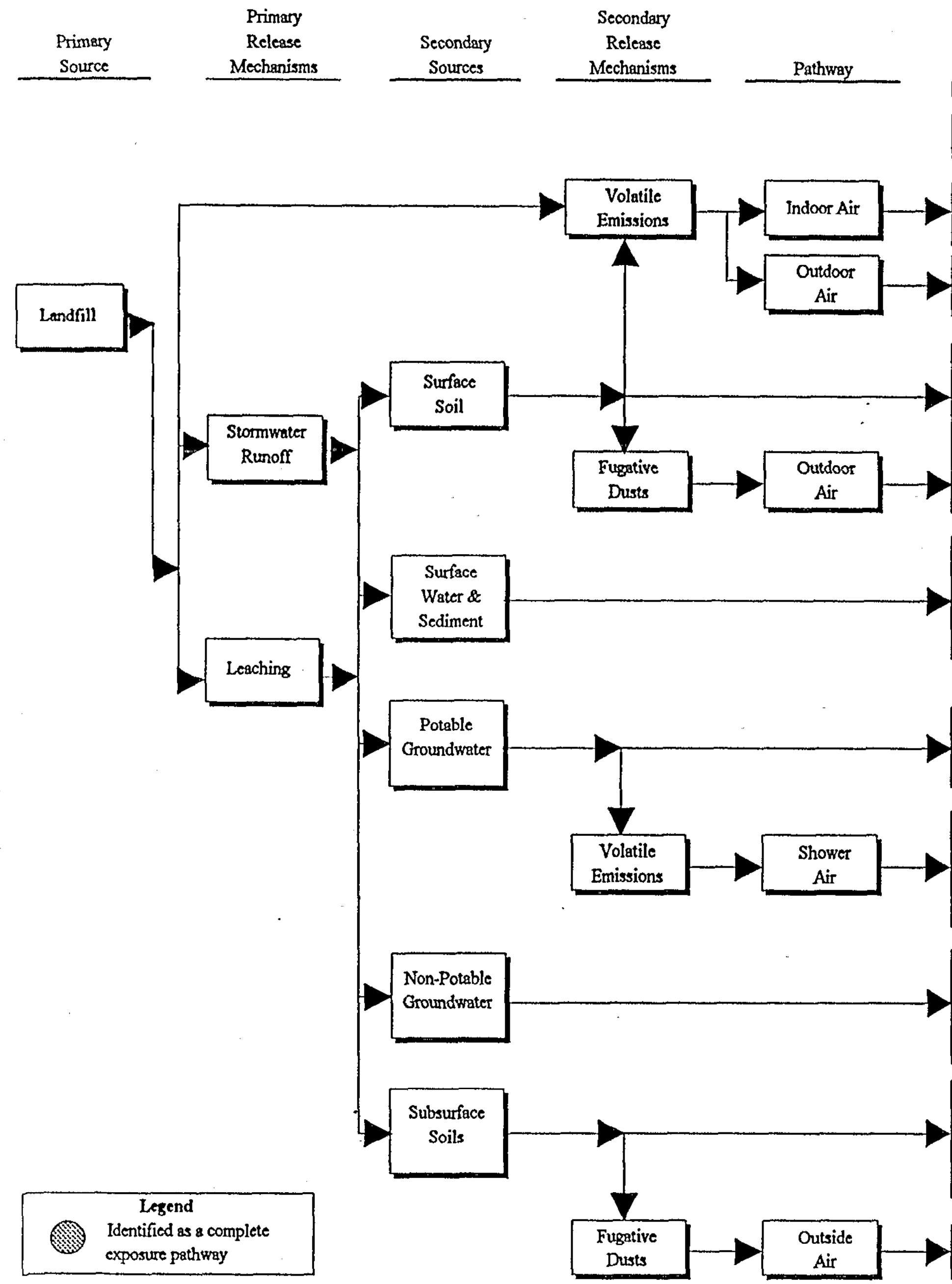
(2) Future resident children could potentially be exposed to COPCs by dermal contact and accidental ingestion of soils, surface waters, and sediments, as well as inhalation of fugitive dusts and VOCs detected in outdoor air, and by the potable use of shallow and deep groundwaters.

(3) Construction workers could potentially be exposed to COPCs by dermal contact and accidental ingestion of subsurface soils, and the inhalation of fugitive dusts emanating from excavated subsurface soils.

* Total site ICR and HI values presented using shallow well location B-MW11A since this location was associated with the most elevated risks in Area B.

SECTION 6.0 FIGURES

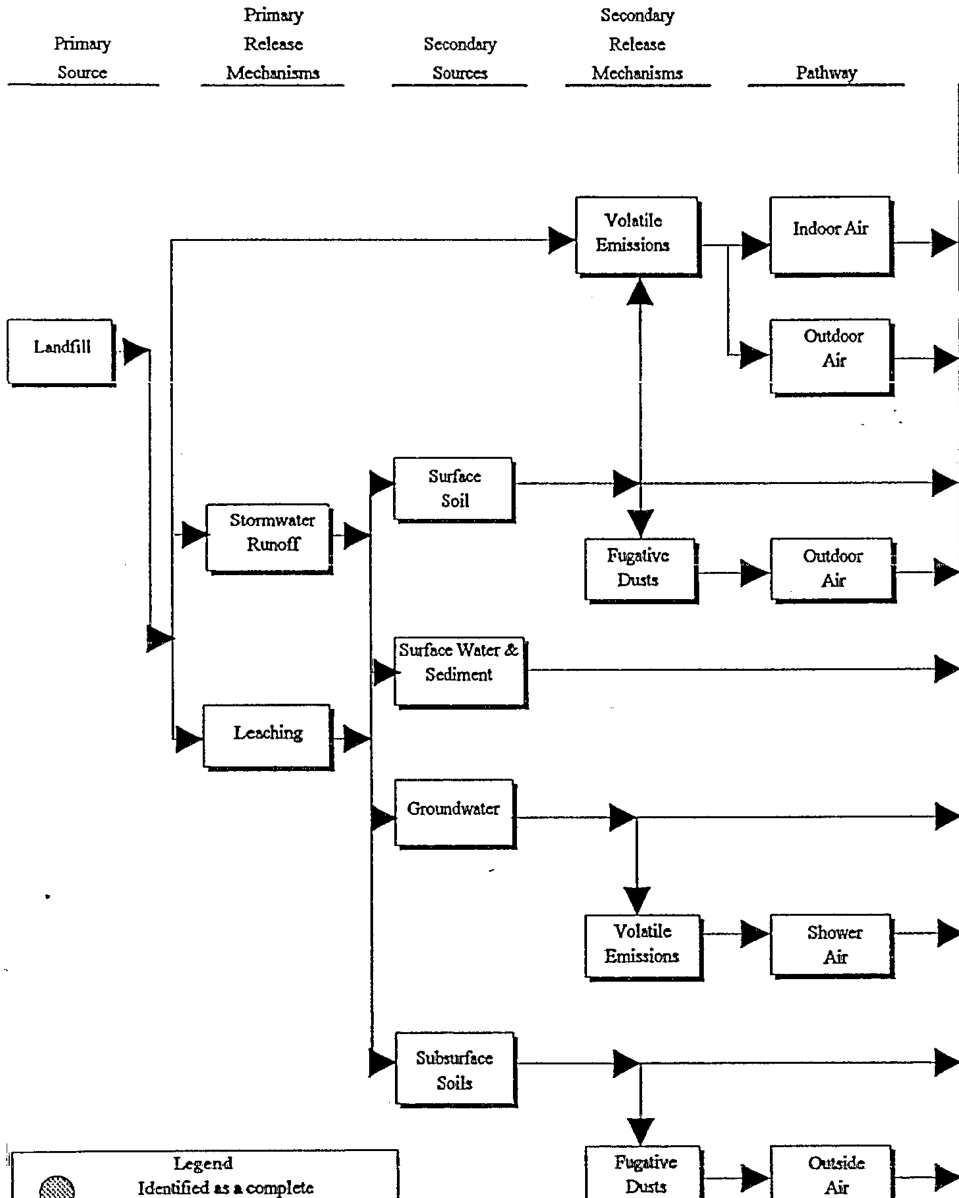
FIGURE 6-1
CONCEPTUAL SITE MODEL
CAMP ALLEN LANDFILL - AREA A
NORFOLK NAVAL BASE, NORFOLK, VIRGINIA



Area A

Exposure Route	Brig Prisoners	Brig Employees	Future Residential Adults	Future Residential Children	Construction Workers	Local Residential Adult	Local Residential Children
Inhalation	●	●					
Inhalation	●	●	●	●		●	●
Ingestion	●	●	●	●			
Dermal Contact	●	●	●	●			
Inhalation	●	●					
Ingestion	●	●	●	●		●	●
Dermal Contact	●	●	●	●		●	●
Ingestion	●	●	●	●			
Inhalation	●		●	●			
Dermal Contact	●		●	●			
Ingestion						●	●
Dermal Contact						●	●
Ingestion					●		
Dermal Contact					●		
Inhalation					●		

FIGURE 6-2
CONCEPTUAL SITE MODEL
CAMP ALLEN LANDFILL - AREA B, AREA B POND, AREA B SCHOOL
NORFOLK NAVAL BASE, NORFOLK, VIRGINIA



	Area B Pond			Area B School				Area B
Exposure Route	Current Adult Workers	Future Residential Adults	Future Residential Children	School Employee	School Children	Future Residential Adult	Future Residential Child	Construction Worker
Inhalation					●	●		
Inhalation	●	●	●	●	●	●	●	
Ingestion	●	●	●	●	●	●	●	
Dermal Contact	●	●	●	●	●	●	●	
Inhalation	●	●	●	●	●	●	●	
Ingestion	●	●	●	●	●	●	●	
Dermal Contact	●	●	●	●	●	●	●	
Ingestion		●	●			●	●	
Inhalation		●	●			●	●	
Dermal Contact		●	●					
Ingestion								●
Dermal Contact								●
Inhalation								●

Legend
● Identified as a complete exposure pathway

7.0 DESCRIPTION OF ALTERNATIVES

For the various contaminated media at the Camp Allen Landfill to be addressed by response actions (soils, surface water/sediment and groundwater), summaries of the remedial alternatives evaluated for each contaminated media are presented in Sections 7.1 through 7.3.

7.1 Soils

Primary contaminants of concern in Area A and Area B soils are VOCs consisting of chlorinated organics, such as trichloroethene, and fuel-related compounds, such as benzene, present in buried waste materials. The soils in Area A and Area B are addressed separately. Remedial alternatives for Area A and Area B are summarized in the following sections.

7.1.1 Area A Soils

The Area A contaminated soils provide a potential on-going source of groundwater contamination at the site. Based on the test pit investigation performed during the pre-design study and the soil cleanup goals (see Section 9.2.1), primary source areas were delineated and were designated Areas A1 and A2 as shown in Figures 5-10 and 5-11, respectively. The total volume of contaminated soil for Area A has been estimated to be approximately 12,800 cubic yards.

Seven potential remedial alternatives for the Area A soil were developed and evaluated in the Feasibility Study. They are:

- A-SO1 - No Action
- A-SO2 - Institutional Controls
- A-SO3 - Asphalt/Geosynthetic Cap Over Brig Area with Institutional Controls
- A-SO4 - Composite Cap Over Hot Spot Areas with Institutional Controls
- A-SO5 - In Situ Treatment of Hot Spot Area Soils and Shallow Groundwater Using Dual Phase Vacuum Extraction with Institutional Controls
- A-SO6 - Thermal Treatment of Hot Spot Area Soils with Institutional Controls
- A-SO7 - Disposal of Hot Spot Area Soils in Off-site Hazardous Waste Landfill with Institutional Controls

Except for A-SO1, the No Action alternative, all the alternatives for Area A soils have several common components including maintenance of the existing fence, maintenance of the existing soil cover over the entire Area A (approximately 45 acres), and control of site access and future land use through institutional controls. There are currently no plans to close Naval Base, Norfok or the Camp Allen area; however, in the event of base closure, institutional controls, such as deed restrictions, would limit the Camp Allen Landfill Area to non-residential land use.

A brief description of each alternative, as well as the estimated cost and timeframe to implement the alternative (not including 30-year monitoring or maintenance periods), are provided below:

- A-SO1 - No Action

  Estimated Capital Cost: $0
  Estimated Annual O & M Cost: $20,000 (every five years)
  Estimated Present-Worth Cost: $55,600
  Estimated Implementation Timeframe: none

  No action would be taken to remediate Area A soils or to restrict site access using institutional controls. The estimated O & M cost of $20,000 is for five-year site reviews.

- A-SO2 - Institutional Controls

  Estimated Capital Cost: $0
  Estimated Annual O & M Cost: $17,557 (annually)
  $37,557 (every five years)
  Estimated Present-Worth Cost: $325,500
  Estimated Implementation Timeframe: less than one year

  The current land use at the site is industrial/military. In the event of base closure, deed restrictions would be implemented to limit the Area A Landfill to non-residential land use. Legal procedures associated with implementation of deed restrictions would require less than one year to complete. In addition, the existing fence, which separates Area A Landfill from Glenwood Park, would be maintained to limit site access, and the existing soil cover over Area A would be maintained. The estimated O&M costs are for fence maintenance, soil cover maintenance, and five-year site reviews. Costs for implementation of deed restrictions were not estimated.

- A-SO3 - Asphalt/Geosynthetic Cap Over Brig Area with Institutional Controls

  Estimated Capital Cost: $927,200
  Estimated Annual O & M Cost: $17,557 (annually)
  $95,653 (every five years)
  Estimated Present-Worth Cost: $1,877,900
  Estimated Implementation Timeframe: less than one year, once construction begins

  An impermeable asphalt/geosynthetic cap would be placed over the brig area and the area immediately west of the brig area (an area of approximately 12 acres) to cover the hot spot areas identified in Area A1 during the pre-design investigation. The cap would minimize infiltration of surface water, thus reducing leaching and transport of contaminants from the contaminated soil. In addition, the cap would prevent potential exposure to contaminated soil. The technologies for grading and cap installation are demonstrated and commercially available. Periodic inspection and maintenance of the cap would be required.

- A-SO4 - Composite Cap Over Hot Spot Areas with Institutional Controls

  Estimated Capital Cost: $465,300
  Estimated Annual O & M Cost: $19,395 (annually)
  $39,395 (every five years)
  Estimated Present-Worth Cost: $819,100
  Estimated Implementation Timeframe: less than one year, once construction begins

  An impermeable composite cap would be placed over the hot spot areas identified in Areas A1 and A2 during the pre-design investigation (a total area of approximately 1 acre). The cap would minimize infiltration of surface water, thus reducing leaching and transport of contaminants from the contaminated soil. In addition, the cap would prevent potential exposure to contaminated soil. The technologies for grading and cap installation are demonstrated and commercially available. Periodic inspection and maintenance of the cap would be required.

- A-SO5 - In Situ Treatment of Hot Spot Area Soils and Shallow Groundwater Using Dual Phase Vacuum Extraction with Institutional Controls

Estimated Capital Cost: $490,700
Estimated Annual O & M Cost: $108,066 (years 1 - 4)
$139,022 (year 5)
$17,557 (years 6 - 30)
Estimated Present-Worth Cost: $1,216,700
Estimated Implementation Timeframe: five years, or possibly longer

The contaminated soil in the hot spot areas identified during the pre-design investigation would be treated with a dual phase vacuum extraction (DPVE) system, removing contaminated soil gas and shallow groundwater for subsequent treatment. The estimated volume of soil to be treated is 12,800 cubic yards. DPVE is a method to remediate soil and shallow groundwater using a single extraction system. The system uses a high vacuum to strip the unsaturated zone of VOCs, while simultaneously removing groundwater (in liquid and vapor form) from the shallow aquifer. The dual phase vacuum extraction and treatment system would consist of several major components. The extraction system would include the extraction wells (approximately 5-10 wells) and below-grade interconnecting well piping. The treatment system would include a liquid ring vacuum pump system, an air/water separator system, a vapor phase carbon adsorption system, and a groundwater transfer pump. The liquid ring vacuum pump system would entrain vapor and liquid from the extraction wells. This two-phase stream would be entrained in the air/water separator and split into a liquid and vapor stream. The vapor phase would be treated with activated carbon, and the liquid would be sent to the on-site groundwater treatment plant, which is part of the proposed response action for groundwater at the site.

As noted in Section 2.4.3, a pilot test was conducted in Area A1 and Area A2 to determine the feasibility of the DPVE technology in each area. Test results indicated that DPVE treatment is well-suited for Area A1 but not appropriate for Area A2 due to the higher permeability soils.

DPVE technology is innovative, but is very similar to soil vapor extraction (SVE) technology, which has been used extensively. The equipment and technology for

DPVE systems are demonstrated and commercially available. The major operational requirements include periodic (e.g., monthly) replacement of the carbon canisters used to treat soil gas and on-site treatment of the water collected in the air/water separator. This alternative would be implemented in conjunction with a groundwater treatment alternative, and periodic monitoring of off-gas contaminant concentrations, water level checks in the air/water separator, and servicing of the air compressor would also need to be performed.

Since Area A is a landfill, the remedial action objective for the soils is groundwater protection rather than soil cleanup. Therefore, achievement of this objective would not necessarily be based on attainment of the developed soil cleanup goals (see Section 9.2.1) since they represent theoretical values calculated through modeling. In addition, the cleanup goals were developed using conservative assumptions and may not be representative of actual site conditions. Therefore, achievement of groundwater protection would be determined through development of treatment system performance curves and through evaluation of actual environmental monitoring results (i.e., via ongoing monitoring of contaminant levels in groundwater and in the extracted vapors from the in situ vacuum extraction system). Soil contaminant concentrations may eventually reach asymptotic levels below which contaminant levels cannot be reduced via in situ vacuum extraction. It is estimated that the asymptotic levels would be reached within a 5-year period. If treatment system performance curves indicate that the cleanup goals for some or all of the contaminants cannot be achieved, then the soil cleanup goals will be reevaluated. If the soil cleanup goals are achieved, then the levels of VOCs in the soils would be reduced by approximately two orders of magnitude. Contaminant trends would be analyzed using results from the groundwater monitoring program to assess whether any portion of the landfill is acting as a source of groundwater contamination over the long term.

- A-SO6 - Thermal Treatment of Hot Spot Area Soils with Institutional Controls

Estimated Capital Cost: $6,141,500
Estimated Annual O & M Cost: $17,557 (annually)
$37,557 (every five years)
Estimated Present-Worth Cost: $6,467,100
Estimated Implementation Timeframe: less than one year, once construction begins

The contaminated soil in the hot spot areas identified during the pre-design investigation would be treated on site using a low-temperature (i.e., 400-800°F) thermal desorption process. The treatment process involves separation of VOCs and, to a lesser degree, semi-volatile organic compounds (SVOCs) from soil by heating the waste in a desorption chamber. Desorbed organic vapors are subsequently condensed and recovered as liquid for subsequent disposal (i.e., off-site incineration). This process is expected to remove more than 99 percent of the VOCs and 80 to 99 percent of SVOCs (depending on their boiling points) from the soil. Thus, the levels of VOCs would be reduced well below the soil cleanup goals (i.e., reduced by more than two orders of magnitude). The treated soil would be backfilled on site, assuming that the established soil cleanup levels have been achieved.

The technologies proposed for excavation, material handling, and thermal treatment are all demonstrated and commercially available. Excavation could be more difficult if the source area is located adjacent to a building or in an area containing many underground utilities. Material handling would also be more difficult if the contaminated soils contain a large amount of debris, such as glass, paper, metallic objects, or construction materials. Thermal treatment technologies are expected to be technically feasible and implementable. However, since a residential community is located adjacent to the base property, there could be public opposition to operation of a thermal treatment unit on site. An on-site trial burn with extensive stack and site perimeter air monitoring could be required to satisfy regulatory agency and/or public concerns.

- A-SO7 - Disposal of Hot Spot Area Soils in Off-site Hazardous Waste Landfill with Institutional Controls

  Estimated Capital Cost: $9,867,900
  Estimated Annual O & M Cost: $17,557 (annually)
  $37,557 (every five years)
  Estimated Present-Worth Cost: $10,193,500
  Estimated Implementation Timeframe: less than one year, once construction begins

  The contaminated soil in the hot spot areas identified during the pre-design investigation would be excavated and transported off site for disposal at a RCRA-permitted hazardous waste landfill. The excavation would be backfilled with clean soil from an off-site source.

  The technologies proposed for excavation, material handling, and off-site disposal are all demonstrated and commercially available. Material handling would also be more difficult in Area A2 where the contaminated soils contain some debris and construction materials (i.e., concrete). Adequate landfill capacity is not expected to be a concern. The nearest facility is located approximately 375 miles from the site.

7.1.2 Area B Soils

As discussed in Section 2.4.1, a removal action for the Area B Landfill was initiated in the summer of 1994 and has been completed. The removal action involved excavation of contaminated soil, debris, and drums in several hot spot areas and off-site disposal at a RCRA-permitted hazardous waste landfill or incinerator. The objective of the removal action was to remove the sources of groundwater contamination within the Area B Landfill so that no further remedial actions would be required for Area B soils. Therefore, source control alternatives (such as capping and treatment alternatives), which were developed for Area A soils, were not developed for Area B soils.

Two potential remedial alternatives for the Area B soil were developed and evaluated. They are:

- B-SO1 - No Action
- B-SO2 - Institutional Controls

A brief description of each alternative, as well as the estimated cost and timeframe to implement the alternative (not including 30-year monitoring or maintenance periods), is provided below:

- B-SO1 - No Action

  Estimated Capital Cost: $0
  Estimated Annual O & M Cost: $20,000 (every five years)
  Estimated Present-Worth Cost: $55,600
  Estimated Implementation Timeframe: none

  No action would be taken to remediate Area B soils or to restrict site access using institutional controls. The estimated O & M cost of $20,000 is for five-year site reviews.

- B-SO2 - Institutional Controls

  Estimated Capital Cost: $0
  Estimated Annual O & M Cost: $600 (annually)
  $20,000 (every five years)
  Estimated Present-Worth Cost: $63,200
  Estimated Implementation Timeframe: less than one year

  The current land use at the site is industrial/military. In the event of base closure, deed restrictions would be implemented to limit the Area B Landfill to non-residential land use. Legal procedures associated with implementation of deed restrictions would require less than one year to complete. In addition, the existing perimeter fence would be maintained to limit site access. The estimated O&M costs are for fence maintenance and five-year site reviews. Costs for implementation of deed restrictions were not estimated.

7.2 Surface Water/Sediment (Areas A and B)

Sediment and surface water in the drainage channels surrounding Areas A and B were found to contain isolated areas of elevated organic and inorganic constituents. However, contamination levels do not suggest a need for active remediation of surface water/sediment for the following reasons:

- Relatively low levels of contaminants were detected in site surface water and sediments.

- Migration of contaminants from the surface water and sediments to groundwater is not considered to be a pathway of concern since shallow groundwater generally discharges to the drainage ditches (i.e., surface water generally does not recharge the shallow groundwater).

- Results of the baseline risk assessment for Area A and Area B surface water and sediment indicate no exceedances of human health criteria associated with exposure (via ingestion and dermal contact) to surface water or sediment under the current land uses. Therefore, under the current land uses at Areas A and B, no unacceptable human health effects would be expected from exposure to surface water and sediment.

- Source control measures that have been implemented at Area B (removal action), and source control measures that are planned for Area A, are expected to improve the quality of surface water and sediment in these areas over time.

Two potential remedial alternatives for the Area A and B surface water/sediment were developed and evaluated. They are:

- SD1 - No Action
- SD2 - Institutional Controls with Monitoring

A brief description of each alternative, as well as the estimated cost and timeframe to implement the alternative (not including 30-year monitoring periods), are provided below:

- SD1 - No Action

  Estimated Capital Cost: $0
  Estimated Annual O & M Cost: $20,000 (every five years)
  Estimated Present-Worth Cost: $55,600
  Estimated Implementation Timeframe: none

No action would be taken to remediate Area A or B surface water or sediments or to restrict site access using institutional controls. The estimated O & M cost of $20,000 is for five-year site reviews. Under the recommended soil alternative, the existing fence in Areas A and B would be maintained to limit site access, and the existing soil cover over Area A would be maintained. As previously discussed, the proposed remediation of the soil and groundwater in the area will most likely result in a decrease in contaminant levels in surface water/sediment over time.

- SD2 - Institutional Controls with Monitoring

Estimated Capital Cost: $0
Estimated Annual O & M Cost: $50,477 (annually)
$70,477 (every five years)
Estimated Present-Worth Cost: $831,600
Estimated Implementation Timeframe: less than one year

The current land use at the site is industrial/military. In the event of base closure, deed restrictions would be implemented to limit the area to non-residential land use. Legal procedures associated with implementation of deed restrictions would require less than one year to complete. Under the recommended soil alternative, the existing fence in Areas A and B would be maintained to limit site access, and the existing soil cover over Area A would be maintained.

In addition, a surface water and sediment monitoring program would be implemented (estimated annual cost $50,477) to track trends in surface water and sediment contamination levels. As previously discussed, the proposed remediation of the soil and groundwater in the area will most likely result in a decrease in contaminant levels in surface water and sediment over time. The monitoring program would provide information required to track trends in contaminant levels over time in these media.

7.3 Groundwater

Groundwater contamination is present both in the water table (shallow) aquifer and the upper Yorktown (deep) Aquifer at the site. The primary contaminants of concern in site groundwater are

VOCs, with trace amounts of other contaminants. Elevated levels of some inorganics were also detected, but are believed to be associated with total suspended solids rather than dissolved in the groundwater.

The groundwater in various areas of the site is addressed separately. Remedial alternatives evaluated for Area A1, Area A2 and Area B are summarized in the following sections.

7.3.1 Area A1 Groundwater

As will be discussed in Section 9.0 of this report, the recommended response action for contaminated soil in Area A1 is Alternative A-SO5, in situ treatment by dual phase vacuum extraction (DPVE). The DPVE system is able to extract both soil and shallow groundwater contamination with a single system. This benefit is especially valuable since it has been shown that the conventional pump and treat method would not be feasible for remediation of the water table aquifer in Area A1 due to its very low hydraulic conductivity. The shallow groundwater extracted by the DPVE system will be pumped to the proposed on-site treatment plant for contaminated groundwater. Since remediation of the water table aquifer in Area A1 will be addressed by the proposed DPVE system, remedial alternatives were not developed for the water table aquifer in this area.

Three potential remedial alternatives for Area A1 groundwater were developed and evaluated. They are:

- A1-GW1 - No Action with Monitoring
- A1-GW2 - Institutional Controls with Monitoring
- A1-GW3 - Protection of the Yorktown Aquifer for Beneficial Use through Extraction and Treatment, Institutional Controls, and Monitoring

A brief description of each alternative, as well as the estimated cost and timeframe to implement the alternative (not including 30-year monitoring or maintenance periods), is provided below:

- A1-GW1 - No Action with Monitoring

Estimated Capital Cost: $0
Estimated Annual O & M Cost: $38,600 (years 1 - 10)
$19,600 (years 11 - 20)
$10,100 (years 21 - 30)
$20,000 (every five years)
Estimated Present-Worth Cost: $476,700
Estimated Implementation Timeframe: none

No action would be taken to actively remediate the upper Yorktown Aquifer in Area A1 or to restrict site access using institutional controls. However, since a primary source area and the water table aquifer within Area A1 will be remediated by DPVE (see Alternative A-SO5), contaminant levels in groundwater in the Yorktown Aquifer may gradually decrease through dilution and natural attenuation. A groundwater monitoring program would be used to assess trends in groundwater quality over time, as discussed below.

Under this alternative, a groundwater monitoring program would be implemented in Area A1. Groundwater monitoring would be conducted on a quarterly basis until a stable or decreasing trend in contaminant levels is observed. Then the frequency of monitoring would be reduced to a semi-annual or annual basis. For cost estimating purposes, it was assumed quarterly monitoring would occur in years 1 to 10, semi-annual monitoring would occur in years 11 to 20, and annual monitoring would occur in years 21 to 30. Additionally, it was assumed that seven monitoring wells and three perimeter monitoring wells in Area A1 would be included in the monitoring program.

- A1-GW2 - Institutional Controls with Monitoring

  Estimated Capital Cost: $0
  Estimated Annual O & M Cost: $38,600 (years 1 - 10)
  $19,600 (years 11 - 20)
  $10,100 (years 21 - 30)
  $20,000 (every five years)
  Estimated Present-Worth Cost: $476,700
  Estimated Implementation Timeframe: less than one year

  The current land use at the site is industrial/military. Under this alternative, existing institutional controls would be maintained to prevent groundwater usage at Camp Allen. There are currently no plans to close Naval Base, Norfolk or the Camp Allen area. However, if the base were to close at some time in the future, deed restrictions would be implemented to limit nonpotable use and prevent potable use of contaminated groundwater. Legal procedures associated with implementation of deed restrictions would require less than one year to complete.

  Since a primary source area and the water table aquifer within Area A1 will be remediated by DPVE (see Alternative A-SO5), contaminant levels in groundwater in the Yorktown Aquifer may gradually decrease through dilution and natural attenuation. A groundwater monitoring program would be implemented, as described under Alternative A1-GW1, to assess trends in groundwater quality over time.

- A1-GW3 - Protection of the Yorktown Aquifer for Beneficial Use Through Extraction and Treatment, Institutional Controls, and Monitoring

  Estimated Capital Cost: $6,108,500
  Estimated Annual O & M Cost: $187,300 (years 1 - 10)
  $168,300 (years 11 - 20)
  $158,800 (years 21 - 30)
  $20,000 (every five years)
  Estimated Present-Worth Cost: $8,870,200
  Estimated Implementation Timeframe: 10 to 20 years, or possibly longer

  This alternative for groundwater in Area A1 would involve protection of the Yorktown Aquifer for beneficial use (i.e., potential drinking water source) through extraction and on-site treatment. Groundwater in the upper Yorktown Aquifer would be extracted through a series of pumping wells (e.g., three to six wells, approximately 65 feet deep) and would be pumped to an on-site treatment system. The pumping rate would be designed to contain the current extent of contamination. If possible, the system would be operated until groundwater cleanup goals (federal MCLs for Yorktown Aquifer) are achieved. An estimated groundwater pumping rate of 82 gallons per minute (gpm) would be required to contain the current extent of contamination in Area A1 as shown in Figure 5-7.

The groundwater treatment process would include metals removal via clarification and filtration, and removal of organics via air stripping and carbon adsorption. The groundwater treatment system included under this alternative has been sized to accommodate flows from Areas A1, A2 and B plus a contingency. This approach is more cost-effective than constructing individual treatment systems for the three areas. Note that the cost for this alternative includes the entire capital cost for construction of the groundwater treatment system for all three areas of the site.

Air stripping and carbon adsorption are commonly used for groundwater remediation for treatment of organic contaminants. Equipment and services for these systems are offered by numerous commercial vendors. The most common problem associated with air strippers is clogging and channeling in the packing materials in packed towers and clogging of air diffusers in diffused aeration strippers. The pretreatment system would remove suspended solids and any nuisance metals that may cause clogging. Construction of a permanent building would be required to house the treatment systems.

Among other factors, the time to achieve groundwater cleanup goals is dependent on the nature and extent of the sources, which are difficult to characterize within a landfill. Therefore, the time to achieve these cleanup goals cannot accurately be predicted at this time. It is possible that cleanup goals could require 10 to 20 years, or longer, to achieve. Also, MCLs may be impossible to achieve since it has been demonstrated that groundwater contaminant concentrations typically reach asymptotic levels, which may exceed MCLs. Performance curves would be periodically (e.g., annually) developed to monitor the effectiveness of the groundwater remediation system. If the performance curves indicate that asymptotic levels have been reached that exceed MCLs for some contaminants, then the cleanup goals may be reevaluated at that time.

With respect to initial risk associated with potable use of the Yorktown Aquifer, HI values of 12 and 7.5 and ICR values of 5.4×10^{-3} and 8.9×10^{-3} were calculated for child and adult receptors, respectively (Table 6-3). If the MCLs are ultimately achieved, then these initial risks would be reduced to acceptable levels (i.e., HI <1.0 and ICR $<1 \times 10^{-4}$).

Additionally, institutional controls and a groundwater monitoring program would be implemented, as described under Alternatives A1-GW1 and A1-GW2.

7.3.2 Area A2 Groundwater

Three potential remedial alternatives for Area A2 groundwater were developed and evaluated in the Feasibility Study. They are:

- A2-GW1 - No Action with Monitoring
- A2-GW2 - Institutional Controls with Monitoring
- A2-GW3 - Protection of the Yorktown Aquifer for Beneficial Use through Extraction and Treatment, Institutional Controls and Monitoring

When the Feasibility Study was prepared, it was believed that remediation of the water table aquifer in Area A2 could be addressed by the DPVE system. Therefore, an extraction and treatment remedial alternative was not developed for the water table aquifer in this area in the Feasibility Study.

Since completion of the Feasibility Study, a DPVE pilot test has been performed in Area A2. Based on the results of the pilot test, extraction of groundwater from the water table aquifer using conventional submersible pumps appears to be better suited for Area A2 than DPVE technology. Therefore, a fourth groundwater alternative, A2-GW4, was added to the Proposed Remedial Action Plan (PRAP) to address the water table aquifer in this area as follows:

- Alternative A2-GW4 - Protection of the Water Table Aquifer for Beneficial Use Through Extraction and Treatment, Institutional Controls, and Monitoring.

A brief description of each alternative, as well as the estimated cost and timeframe to implement the alternative (not including 30-year monitoring or maintenance periods), is provided below:

- A2-GW1 - No Action with Monitoring

  Estimated Capital Cost: $0
  Estimated Annual O & M Cost: $38,600 (years 1 - 10)
  $19,600 (years 11 - 20)
  $10,100 (years 21 - 30)
  $20,000 (every five years)
  Estimated Present-Worth Cost: $476,700
  Estimated Implementation Timeframe: none

  No action would be taken to actively remediate the upper Yorktown Aquifer in Area A2 or to restrict site access using institutional controls. Contaminant levels in groundwater in the Yorktown Aquifer may gradually decrease through dilution and natural attenuation. A groundwater monitoring program would be used to assess trends in groundwater quality over time, as discussed below.

  Under this alternative, a groundwater monitoring program would be implemented in Area A2. Groundwater monitoring would be conducted on a quarterly basis until a stable or decreasing trend in contaminant levels is observed. Then the frequency of monitoring would be reduced to a semi-annual or annual basis. For cost estimating purposes, it was assumed quarterly monitoring would occur in years 1 to 10, semi-annual monitoring would occur in years 11 to 20, and annual monitoring would occur in years 21 to 30. Additionally, it was assumed that seven monitoring wells and three perimeter monitoring wells in Area A2 would be included in the monitoring program.

- A2-GW2 - Institutional Controls with Monitoring

  Estimated Capital Cost: $0
  Estimated Annual O & M Cost: $38,600 (years 1 - 10)
  $19,600 (years 11 - 20)
  $10,100 (years 21 - 30)
  $20,000 (every five years)
  Estimated Present-Worth Cost: $476,700
  Estimated Implementation Timeframe: less than one year

  The current land use at the site is industrial/military. Under this alterative, existing institutional controls would be maintained to prevent groundwater usage at Camp Allen. There are currently no plans to close Naval Base, Norfolk or the Camp Allen area. However, if the base were to close at some time in the future, deed restrictions would be implemented to limit nonpotable use and prevent potable use of contaminated groundwater. Legal procedures associated with implementation of deed restrictions would require less than one year to complete.

  Contaminant levels in groundwater in the Yorktown Aquifer may gradually decrease through dilution and natural attenuation. A groundwater monitoring program would be implemented, as described under Alternative A2-GW1, to assess trends in groundwater quality over time.

- A2-GW3 - Protection of the Yorktown Aquifer for Beneficial Use Through Extraction and Treatment, Institutional Controls, and Monitoring

  Estimated Capital Cost: $0 (capital cost for treatment system under Alternative A1-GW3)
  Estimated Annual O & M Cost: $59,400 (years 1 - 10)
  $40,400 (years 11 - 20)
  $30,900 (years 21 - 30)
  $20,000 (every five years)
  Estimated Present-Worth Cost: $796,000
  Estimated Implementation Timeframe: 10 to 20 years, or possibly longer

  This alternative for groundwater in Area A2 would involve protection of the Yorktown Aquifer for beneficial use (i.e., potential drinking water source) through extraction and on-site treatment. Groundwater in the upper Yorktown Aquifer would be extracted through a series of pumping wells (e.g., three to six wells approximately 65 feet deep) and would be pumped to an on-site treatment system.

The pumping rate is designed to contain the current extent of contamination. If possible, the system would be operated until groundwater cleanup goals (federal MCLs for Yorktown Aquifer) are achieved. An estimated groundwater pumping rate of 82 gpm would be required to contain the current extent of contamination in Area A2 as shown in Figure 5-7.

The groundwater treatment process would include metals removal via clarification and filtration, and removal of organics via air stripping and carbon adsorption. The groundwater treatment system included under Alternative A1-GW3 has been sized to accommodate flows from Areas A1, A2 and B plus a contingency. This approach is more cost-effective than constructing individual treatment systems for the three areas. Note that the entire capital cost for construction of the groundwater treatment system for all three areas of the site is included under Alternative A1-GW3. Therefore, capital costs for the groundwater treatment system are not included in this alternative. Annual O&M costs for this alternative include the incremental treatment costs associated with treating the additional flow (82 gpm) from Area A2.

Air stripping and carbon adsorption are commonly used for groundwater remediation for treatment of organic contaminants. Equipment and services for these systems are offered by numerous commercial vendors. The most common problem associated with air strippers is clogging and channeling in the packing materials in packed towers and clogging of air diffusers in diffused aeration strippers. The pretreatment system would remove suspended solids and any nuisance metals that may cause clogging. Construction of a permanent building would be required to house the treatment system.

Among other factors, the time to achieve groundwater cleanup goals is dependent on the nature and extent of the sources, which are difficult to characterize within a landfill. Therefore, the time to achieve these cleanup goals cannot accurately be predicted at this time. It is possible that cleanup goals could require 10 to 20 years, or longer, to achieve. Also, MCLs may be impossible to achieve since it has been demonstrated that groundwater contaminant concentrations typically reach asymptotic levels, which may exceed MCLs. Performance curves would be periodically (e.g., annually) developed to monitor the effectiveness of the groundwater remediation system. If the performance curves indicate that asymptotic levels have been reached that exceed MCLs for some contaminants, then the cleanup goals may be reevaluated at that time.

With respect to initial risks associated with potable use of the Yorktown Aquifer, HI values of 12 and 7.5 and ICR values of 5.4×10^{-3} and 8.9×10^{-3} were calculated for child and adult receptors, respectively (Table 6-3). If the MCLs are ultimately achieved, then these initial risks would be reduced to acceptable levels (i.e., HI <1.0 and ICR $<1 \times 10^{-4}$).

Additionally, institutional controls and a groundwater monitoring program would be implemented, as described under Alternatives A2-GW1 and A2-GW2.

- A2-GW4 - Protection of the Water Table Aquifer for Beneficial Use Through Extraction and Treatment, Institutional Controls, and Monitoring

Estimated Capital Cost: $0 (capital cost for treatment system under Alternative A1-GW3)
Estimated Annual O & M Cost: $8,900 (years 1 - 10)
$6,200 (years 11 - 20)
$4,900 (years 21 - 30)
$20,000 (every five years)
Estimated Present-Worth Cost: $168,000
Estimated Implementation Timeframe: 10 to 20 years, or possibly longer

This alternative for groundwater in Area A2 would involve protection of the water table aquifer for its beneficial use (i.e., nonpotable use) through extraction and on-site treatment. Groundwater in the water table aquifer would be extracted through a series of shallow pumping wells (e.g., two to three wells, approximately 25 feet deep). Extracted groundwater would be pumped to an on-site treatment system. The pumping rate is designed to contain the current extent of contamination. If possible, the system would be operated until groundwater cleanup goals (see Section 9.2.2) are achieved. An estimated groundwater pumping rate of 6 gpm would be required to contain the current extent of contamination in Area A2 as shown in Figure 5-7.

The groundwater treatment process would include metals removal via clarification and filtration, and removal of organics via air stripping and carbon adsorption. The groundwater treatment system included under Alternative A1-GW3 has been sized to accommodate flows from Areas A1, A2 and B plus a contingency. This approach is more cost-effective than constructing individual treatment systems for the three areas. Note that the entire capital cost for construction of the groundwater treatment system for all three areas of the site is included under Alternative A1-GW3. Therefore, capital costs for the groundwater treatment system are not included in this alternative. Annual O&M costs for this alternative include the incremental treatment costs associated with treating the additional flow (6 gpm) from Area A2.

Among other factors, the time to achieve groundwater cleanup goals is dependent on the nature and extent of the sources, which are difficult to characterize within a landfill. Therefore, the time to achieve these cleanup goals cannot accurately be predicted at this time. It is possible that cleanup goals could require 10 to 20 years, or longer, to achieve.

Since the groundwater cleanup goals for the water table aquifer were based on an ICR of 1×10^{-6} and a hazard quotient (HQ) of 1.0, achievement of these goals would ensure that remaining cumulative risks are within acceptable levels for nonpotable use (i.e., HI <1.0 and ICR <1×10^{-4}).

Institutional controls and a groundwater monitoring program would also be implemented under this alternative, as described under Alternatives A2-GW1 and A2-GW2.

7.3.3 Area B Groundwater

In situ treatment of soil and shallow groundwater is not proposed for Area B under Alternative A-SO5, as was done for Area A. Therefore, since remediation of the water table aquifer in Area B has not been addressed under another alternative, remedial alternatives for Area B groundwater include remediation of both the water table aquifer and the Yorktown Aquifer.

Three potential remedial alternatives for Area B groundwater were developed and evaluated. They are:

- B-GW1 - No Action with Monitoring
- B-GW2 - Institutional Controls with Monitoring
- B-GW3 - Protection of the Water Table and Yorktown Aquifers for Beneficial Use through Extraction and Treatment, Institutional Controls, and Monitoring

A brief description of each alternative, as well as the estimated cost and timeframe to implement the alternative (not including 30-year monitoring or maintenance periods), is provided below:

- B-GW1 - No Action with Monitoring

  Estimated Capital Cost: $0
  Estimated Annual O & M Cost: $38,600 (years 1 - 10)
  $19,600 (years 11 - 20)
  $10,100 (years 21 - 30)
  $20,000 (every five years)
  Estimated Present-Worth Cost: $476,700
  Estimated Implementation Timeframe: none

  No action would be taken to actively remediate Area B groundwater or to restrict site access using institutional controls. However, since a primary source area within Area B has been permanently removed through a removal action (see Section 5.2.1), contaminant levels in groundwater in Area B should gradually decrease through dilution and natural attenuation. A groundwater monitoring program would be used to assess trends in groundwater quality over time, as discussed below.

  Under this alternative, a groundwater monitoring program would be implemented in Area B. Groundwater monitoring would be conducted on a quarterly basis until a stable or decreasing trend in contaminant levels is observed. Then the frequency of monitoring would be reduced to a semi-annual or annual basis. For cost estimating purposes, it was assumed quarterly monitoring would occur in years 1 to 10, semi-annual monitoring would occur in years 11 to 20, and annual monitoring would occur in years 21 to 30. Additionally, it was assumed that ten monitoring wells in Area B would be included in the monitoring program.

- B-GW2 - Institutional Controls with Monitoring

  Estimated Capital Cost: $0
  Estimated Annual O & M Cost: $38,600 (years 1 - 10)
  $19,600 (years 11 - 20)
  $10,100 (years 21 - 30)
  $20,000 (every five years)
  Estimated Present-Worth Cost: $476,700
  Estimated Implementation Timeframe: less than one year

  The current land use at the site is industrial/military. Under this alterative, existing institutional controls would be maintained to prevent groundwater usage at Camp Allen. There are currently no plans to close Naval Base, Norfolk or the Camp Allen area. However, if the base were to close at some time in the future, deed restrictions would be implemented to limit nonpotable use and prevent potable use of contaminated groundwater. Legal procedures associated with implementation of deed restrictions would require less than one year to complete.

  Since a primary source area within Area B has been remediated through a removal action (see Section 5.2.1), contaminant levels in groundwater in Area B should gradually decrease through dilution and natural attenuation. A groundwater monitoring program would be implemented, as described under Alternative B-GW1, and would be used to assess trends in groundwater quality over time.

- B-GW3 - Protection of the Water Table and Yorktown Aquifers for Beneficial Use Through Extraction and Treatment, Institutional Controls, and Monitoring

  Estimated Capital Cost: $0 (capital cost for treatment system under Alternative A1-GW3)
  Estimated Annual O & M Cost: $62,400 (years 1 - 10)
  $43,400 (years 11 - 20)
  $34,000 (years 21 - 30)
  $20,000 (every five years)
  Estimated Present-Worth Cost: $842,500
  Estimated Implementation Timeframe: 10 to 20 years, or possibly longer

  This alternative for groundwater in Area B would involve protection of the water table aquifer and Yorktown Aquifer for their respective beneficial uses (i.e., potential drinking water source for Yorktown Aquifer and nonpotable use for water table aquifer) through extraction and on-site treatment. Groundwater in the upper Yorktown Aquifer would be extracted through a series of pumping wells (e.g., three wells, approximately 65 feet deep). Groundwater in the water table aquifer would be extracted through a series of shallow pumping wells (e.g., five wells, approximately 25 feet deep). Extracted groundwater from both aquifers would be pumped to an on-site treatment system. The pumping rate is designed to contain the current extent of contamination as shown in Figure 5-7. If possible, the system would be operated until groundwater cleanup goals (see Section 9.2.2) are achieved. An estimated groundwater pumping rate of 42 gpm would be required to contain the current extent of contamination in Area B.

The groundwater treatment process would include metals removal via clarification and filtration, and removal of organics via air stripping and carbon adsorption. The groundwater treatment system included under Alternative A1-GW3 has been sized to accommodate flows from Areas A1, A2 and B plus a contingency. This approach is more cost-effective than constructing individual treatment systems for the three areas. Note that the entire capital cost for construction of the groundwater treatment system for all three areas of the site is included under Alternative A1-GW3. Therefore, capital costs for the groundwater treatment system are not included in this alternative. Annual O&M costs for this alternative include the incremental treatment costs associated with treating the additional flow (42 gpm) from Area B.

Air stripping and carbon adsorption are commonly used for groundwater remediation for treatment of organic contaminants. Equipment and services for these systems are offered by numerous commercial vendors. The most common problem associated with air strippers is clogging and channeling in the packing materials in packed towers and clogging of air diffusers in diffused aeration strippers. The pretreatment system would remove suspended solids and any nuisance metals that may cause clogging. Construction of a permanent building would be required to house the treatment systems.

Among other factors, the time to achieve groundwater cleanup goals is dependent on the nature and extent of the sources, which are difficult to characterize within a landfill. Therefore, the time to achieve these cleanup goals cannot accurately be predicted at this time. It is possible that cleanup goals could require 10 to 20 years, or longer, to achieve. Also, MCLs may be impossible to achieve since it has been demonstrated that groundwater contaminant concentrations typically reach asymptotic levels, which may exceed MCLs. Performance curves would be periodically (e.g., annually) developed to monitor the effectiveness of the groundwater remediation system. If the performance curves indicate that asymptotic levels have been reached that exceed MCLs for some contaminants, then the cleanup goals may be reevaluated at that time.

With respect to initial risks associated with potable use of the Yorktown Aquifer in Area B, HI values of 4.6 and 2.8 and ICR values of 3.8×10^{-5} and 8.0×10^{-5} were calculated for child and adult receptors, respectively (Table 6-3). Although the ICR is currently within acceptable levels, contaminants were detected in several Yorktown Aquifer monitoring wells at concentrations significantly in excess of the MCLs. Therefore, achievement of the MCLs, if possible, would reduce the HI to less than 1.0 and would also ensure that the cumulative ICR is below the acceptable 1×10^{-4}.

Since the groundwater cleanup goals for the water table aquifer were based on an ICR of 1×10^{-6} and a hazard quotient (HQ) of 1.0, achievement of these goals would ensure that remaining cumulative risks are within acceptable levels for nonpotable use (i.e., HI <1.0 and ICR $<1 \times 10^{-4}$).

Additionally, institutional controls and a groundwater monitoring program would be implemented, as described under Alternatives B-GW1 and B-GW2.

8.0 SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

In this section, alternatives for soil, surface water/sediment, and groundwater are evaluated against nine evaluation criteria to assess their relative performance and to highlight key differences among the alternatives. The nine evaluation criteria have been determined by the USEPA and are presented in the publication, "Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA" (USEPA, 1988). A summary and descriptions of the nine evaluation criteria are presented in Table 8-1.

Summaries of the performance of remedial alternatives for Area A and Area B soils, Areas A and B surface water/sediment, Area A1 groundwater, Area A2 groundwater, and Area B groundwater with respect to seven of the nine evaluation criteria are presented in Tables 8-2 through 8-7.

The two remaining criteria are state acceptance and community acceptance. With respect to state acceptance, both the USEPA and VADEQ (the state) concur with the selected remedies as presented in Section 9.0. The community acceptance criteria will be assessed in the Responsiveness Summary (Section 11.0 of this document) following a review of public comments on the RI/FS Reports and the Proposed Remedial Action Plan (PRAP).

Soil, surface water/sediment, and groundwater alternatives are compared against each other using the seven evaluation criteria in the following sections:

- 8.1 Comparison of Soil Alternatives
- 8.2 Comparison of Surface Water/Sediment Alternatives
- 8.3 Comparison of Groundwater Alternatives

8.1 <u>Comparison of Soil Alternatives</u>

8.1.1 Comparison of Area A Soil Alternatives

A side-by-side comparison of the alternatives for addressing contaminants in Area A soils, based on the seven evaluation criteria used in the previous sections, is presented in Table 8-2. A summary of the alternative comparison based on the seven criteria is provided in the following sections.

Overall Protection: With respect to surface soils, all alternatives would essentially provide a similar level of protection to human health and the environment since little contamination was detected in the surface soils, and potential risks to human health are within acceptable levels. With respect to potential contamination in subsurface soils, Alternative A-SO1 would not provide any additional protection to human health than that currently provided by existing site fencing. Alternative A-SO2 would provide a higher degree of protection through institutional controls and maintenance of the existing landfill soil cover.

Alternatives A-SO1 and A-SO2 would not provide any additional protection of groundwater than that provided by existing pavement and buildings. Alternatives A-SO3 and A-SO4 would provide partial protection of groundwater through capping. The caps would only be partially effective because the landfill is unlined, and wastes are present near, or below, the water table in some areas. The caps would also provide protection against direct contact with potential soil contaminants. Of the seven alternatives, Alternative A-SO6 would provide the maximum level of protection of human health and the environment through removal and active treatment of the hot spots. Alternative A-SO7 would also permanently remove the "hot spot" areas from the site but would not provide any treatment. Alternative A-SO5 would treat the soil and shallow groundwater in the "hot spot" areas in situ, but would not achieve the same degree of contaminant removal from soil as Alternative A-SO6. Additionally, based on the results of a DPVE pilot study, Alternative A-SO5 is no longer recommended for Area A2.

Compliance with ARARs: There are no contaminant-specific ARARs available for soil. Cap designs under Alternatives A-S03 and A-S04 would comply with applicable RCRA and state regulations. Air emissions generated under Alternatives A-SO5, A-SO6, and A-SO7 would be treated to comply with state and federal air standards. Any hazardous wastes generated during implementation of Alternatives A-SO5, A-SO6, and A-SO7 would be handled, containerized, transported, and disposed in accordance with RCRA and state hazardous waste regulations.

Long-term Effectiveness and Permanence: Estimated risk levels for exposure to surface soils are currently within acceptable levels. Therefore, all alternatives would be protective of human health with respect to surface soils. Alternative A-SO2 would provide a greater degree of protection against possible exposures to subsurface contamination through deed restrictions. lternatives A-SO1 and A-SO2 would not provide a permanent solution in the sense that the "hot spots" would continue to provide sources of groundwater contamination. Alternatives A-SO3 and A-SO4 would provide partial protection of groundwater through capping. Under Alternatives A-SO5, A-SO6, and A-SO7, "hot spot" areas would be permanently removed and/or treated. Based on results of a DPVE pilot study, Alternative A-SO5 is no longer recommended for Area A2.

Reduction of Toxicity, Mobility, or Volume: Alternatives A-SO1 and A-SO2 would not actively reduce the toxicity, mobility, or volume of contaminants in the soils through remedial actions. Some reduction may be achieved under these alternatives through natural processes, such as dispersion, volatilization, and biodegradation. Alternatives A-SO3 and A-SO4 also would not reduce the toxicity, mobility, or volume of contaminants in the soils through treatment. Alternatives A-SO5 and A-SO6 would reduce the toxicity and volume of contaminants in the soils through in situ vacuum extraction and ex situ thermal treatment, respectively. Alternative A-S05 would also reduce the toxicity and volume of contaminants in shallow groundwater through treatment. Alternative A-SO6, thermal treatment, would provide a higher degree of contaminant removal from soil than would vacuum extraction under Alternative A-SO5. Alternative A-SO7 would permanently remove the source areas from the site but would not provide any reduction in toxicity, mobility, or volume through treatment.

Short-term Effectiveness: Alternatives A-SO1 through A-SO4 would not pose potential risks to human health or the environment during implementation. Alternatives A-SO5 and A-SO6 could pose potential risks to these receptors through air emissions; however, treatment and monitoring of air emissions would be used to minimize such potential risks. Implementation of Alternative A-SO7 could pose potential risks to human health and the environment from dust emissions during excavation; however, dust controls would be used minimize such risks. It is estimated that Alternative A-SO5 would require several years to achieve soil cleanup levels that are protective of groundwater, whereas, thermal treatment of the soil under Alternative A-SO6 could be completed within approximately six months once on-site work begins. Alternative A-SO7 could be completed within approximately two months once on-site work begins.

Implementability: There are no implementability considerations under Alternatives A-SO1 and A-S02. Alternative A-SO4 would be easier to implement than Alternative A-SO3 since the cap would cover only limited "hot spot" areas (e.g., 1.0 acre) as opposed to the entire Brig Facility area (approximately 12 acres). Alternative A-SO5 would be easier to implement than Alternatives A-

SO6 and A-SO7 in the sense that excavation and handling of contaminated soils would not be required. In addition, demonstration of compliance with air pollution standards for Alternative A-SO5 could be less complex than those for Alternative A-SO6. There may also be fewer public concerns associated with implementation of Alternative A-SO5 than with Alternative A-SO6. With respect to operation and maintenance requirements, on-site thermal treatment under Alternative A-SO6 would be more complex to operate and monitor than would in situ vacuum extraction under Alternative A-SO5. However, the duration of on-site operation would be less than one year for on-site thermal treatment (assuming extensive trial runs are not needed), compared to potentially several years of operation for Alternative A-SO5. For Alternative A-SO7, off-site disposal capacity is not expected to be a concern.

Cost: The 30-year net present worth costs for the six Area A soil alternatives are summarized below:

- Alternative A-SO1: $55,600
- Alternative A-SO2: $325,500
- Alternative A-SO3: $1,877,900
- Alternative A-SO4: $819,100
- Alternative A-SO5: $1,216,700
- Alternative A-SO6: $6,467,100
- Alternative A-SO7: $10,193,500

With respect to the capping alternatives, A-SO3 and A-SO4, the estimated cost of capping the "hot spot" areas (A-S04) is approximately one-half the cost of capping the entire Brig Facility area (A-S03). With respect to the treatment alternatives, A-SO5 and A-SO6, the estimated cost of treating the "hot spot" area via vacuum extraction ($1,216,700) is approximately one-fifth the cost of thermal treatment ($6,467,100), based on the estimated volume of contamination (i.e., 12,800 cubic yards) and assumed duration of operation (i.e., 5 years for vacuum extraction). Based on the estimated volume of contamination, the estimated cost of disposing the contaminated material off site ($10,193,500) is almost double the cost of treating the "hot spot" area via on-site thermal treatment ($6,467,100).

8.1.2 Comparison of Area B Soil Alternatives

A side-by-side comparison of the alternatives for addressing Area B soils, based on the seven evaluation criteria used in previous sections, is presented in Table 8-3. A summary of the alternative comparison based on the seven criteria is provided below.

Overall Protection: With respect to Area B soils, Alternative B-SO1 would not provide any additional protection to human health than that currently provided by existing site fencing. Alternative B-SO2 would provide a higher degree of protection through institutional controls.

Compliance with ARARs: There are no contaminant-specific ARARs available for soils. In addition, there are no location- or action-specific ARARs associated with either alternative.

Long-term Effectiveness and Permanence: Risks associated with exposure to the surface soils are currently within acceptable levels established under CERCLA under both industrial and residential use scenarios. A removal action has been implemented to remove the sources of groundwater contamination within the Area B landfill. Therefore, both alternatives would provide the same level of groundwater protection following the removal action. Alternative B-SO2 would provide a slightly greater degree of protection against possible exposures to any remaining contamination in the landfill through institutional controls.

Reduction of Toxicity, Mobility, or Volume: Alternatives B-SO1 and B-SO2 would not reduce the toxicity, mobility, or volume of contaminants in the soils through treatment. However, a removal action has been completed for the source areas within the Area B Landfill. Some additional reduction may be achieved under these alternatives through natural processes such as dispersion, volatilization, and biodegradation.

Short-term Effectiveness: Alternatives B-SO1 and B-SO2 would not pose potential risks to human health or the environment during implementation.

Implementability: There are no implementability considerations under Alternative B-SO1 or Alternative B-SO2.

Cost: The estimated 30-year net present worth cost of Alternative B-SO1 is $55,600, which is the cost of performing site reviews every 5 years. The estimated 30-year net present worth cost of Alternative B-SO2 is $63,200 to maintain the existing fencing as well as to conduct 5-year site reviews.

8.2 Comparison of Surface Water/Sediment Alternatives

A side-by-side comparison of the alternatives for addressing site surface water and sediment (Areas A and B), based on the seven evaluation criteria used in previous sections, is presented in Table 8-4. A summary of the alternative comparison based on the seven criteria is provided below.

Overall Protection: There are no unacceptable human health risks associated with exposure to site surface water/sediment. With respect to surface water/sediments, Alternative SD1 would not provide any additional protection to human health than that currently provided by existing site fencing. Alternative SD2 would provide a higher degree of protection through institutional controls. In addition, a surface water and sediment monitoring program would be implemented under Alternative SD2 to track trends in contaminant levels over time in these media.

Compliance with ARARs: There are no contaminant-specific ARARs available for sediments. Although there were sporadic minor exceedances of federal Ambient Water Quality Criteria and Virginia Water Quality Standards, there were no gross exceedances and no clear pattern of exceedances that would suggest a significant problem with site surface water. There are no location- or action-specific ARARs associated with either alternative.

Long-term Effectiveness and Permanence: Under Alternative SD1, there would be no remedial action taken. The human health risks associated with exposure to surface water and sediment would remain the same as in the baseline human health risk assessment (no unacceptable risk). Alternative SD2 would provide a greater degree of protection against possible exposures to potential contamination in surface water and sediments through institutional controls. For both alternatives, source control measures that have been implemented at Area B (removal action), and source control measures that are planned for Area A, are expected to improve the quality of surface water and sediment over time.

Reduction of Toxicity, Mobility, or Volume: Alternatives SD1 and SD2 would not reduce the toxicity, mobility, or volume of contaminants in the sediments through treatment. There may be a reduction in toxicity, mobility, or volume of contaminants in the long term through natural attenuation processes.

Short-term Effectiveness: Alternatives SD1 and SD2 would not pose potential risks to human health or the environment during implementation.

Implementability: There are no implementability considerations under Alternative SD1 or Alternative SD2.

Cost: The estimated 30-year net present worth cost of Alternative SD1 is $55,600 for performing site reviews every 5 years. The estimated 30-year net present worth cost of Alternative SD2 is $831,600 for maintaining existing fencing, implementing a five-year surface water and sediment monitoring program, and conducting five-year site reviews.

8.3 Comparison of Groundwater Alternatives

8.3.1 Comparison of Area A1 Groundwater Alternatives

A side-by-side comparison of the alternatives for addressing contamination in Area A1 groundwater, based on the seven evaluation criteria used in the previous sections, is presented in Table 8-5. A summary of the alternative comparison based on the seven criteria is provided in the following sections.

Overall Protection: Alternatives A1-GW1 and A1-GW2 would not contain or treat contaminated groundwater. Alternative A1-GW3 would achieve protection of the Yorktown Aquifer for beneficial use through groundwater extraction and treatment.

Compliance with ARARs: Alternatives A1-GW1 and A1-GW2 would not treat or contain groundwater contaminated above federal MCLs. However, groundwater on-site and in the vicinity of the site currently is not used for drinking water purposes. Alternative A1-GW3 would comply with these ARARs by containing and potentially restoring contaminated groundwater within the

Yorktown Aquifer to federal MCLs. Under Alternative A1-GW3, treated groundwater and associated air emissions would comply with all local, state, and federal ARARs.

Long-term Effectiveness and Permanence: All alternatives currently provide on-site protection of human health since groundwater is not currently used on site. All alternatives, except Alternative A1-GW1, would provide on-site protection of human health through institutional controls.

Under Alternatives A1-GW1 and A1-GW2, risks would exceed acceptable levels if the groundwater were to be used for potable use. Under Alternative A1-GW3, risks associated with potable use of groundwater would be within acceptable levels following groundwater restoration. Thus, Alternative A1-GW3 would ultimately provide the greatest degree of long-term effectiveness.

Reduction of Toxicity, Mobility, or Volume: Alternatives A1-GW1 and A1-GW2 would not reduce the toxicity, mobility, or volume of contaminants in the groundwater through treatment. Alternative A1-GW3 would reduce the toxicity and volume of contaminants to the established cleanup goals through treatment and would reduce contaminant mobility through extraction.

Short-term Effectiveness: There would be no risks to human health or the environment associated with implementation of Alternatives A1-GW1 and A1-GW2. Under Alternative A1-GW3, air emissions would be regularly monitored to ensure compliance with state and federal air quality standards.

Implementability: Alternative A1-GW3 would be more difficult to implement than would Alternatives A1-GW1 and A1-GW2 since it involves groundwater extraction and treatment. The treatment system components are demonstrated and commercially available.

Cost: The 30-year net present worth costs for the Area A1 groundwater alternatives are summarized below:

- Alternative A1-GW1: $476,700
- Alternative A1-GW2: $476,700
- Alternative A1-GW3: $8,870,200 (includes extraction and treatment system capital cost)

8.3.2 Comparison of Area A2 Groundwater Alternatives

A side-by-side comparison of the alternatives for addressing contamination in Area A2 groundwater, based on the seven evaluation criteria used in the previous sections, is presented in Table 8-6. A summary of the alternative comparison based on the seven criteria is provided in the following sections.

Overall Protection: Alternatives A2-GW1 and A2-GW2 would not contain or treat contaminated groundwater. Alternatives A2-GW3 and A2-GW4 would achieve protection of the water table and Yorktown Aquifers for their beneficial uses through groundwater extraction and treatment.

Compliance with ARARs: Alternatives A2-GW1 and A2-GW2 would not treat or contain groundwater contaminated above federal MCLs. However, groundwater on-site and in the vicinity of the site currently is not used for drinking water purposes. Alternative A2-GW3 would comply with these ARARs by containing and potentially restoring contaminated groundwater within the Yorktown Aquifer to federal MCLs. Under Alternative A2-GW4, groundwater within the water table aquifer would be contained and potentially restored to cleanup levels based on nonpotable use. Under Alternatives A2-GW3 and A2-GW4, treated groundwater and associated air emissions would comply with all local, state, and federal ARARs.

Long-term Effectiveness and Permanence: All alternatives currently provide on-site protection of human health since groundwater is not currently used on site. All alternatives, except Alternative A2-GW1, would provide off-site protection of human health, if necessary, through institutional controls.

Under Alternatives A2-GW1 and A2-GW2, risks would exceed acceptable levels if the groundwater were to be used for potable use. Under Alternatives A2-GW3 and A2-GW4, risks associated with potable and nonpotable use of groundwater, respectively, would be within acceptable levels following groundwater restoration. Thus, Alternatives A2-GW3 and A2-GW4 would ultimately provide the greatest degree of long-term effectiveness.

Reduction of Toxicity, Mobility, or Volume: Alternatives A2-GW1 and A2-GW2 would not reduce the toxicity, mobility, or volume of contaminants in the groundwater through treatment.

Alternatives A2-GW3 and A2-GW4 would reduce the toxicity and volume of contaminants to the established cleanup goals through treatment and would reduce contaminant mobility through extraction.

Short-term Effectiveness: There would be no risks to human health or the environment associated with implementation of Alternatives A2-GW1 and A2-GW2. Under Alternatives A2-GW3 and A2-GW4, air emissions would be regularly monitored to ensure compliance with state and federal air quality standards.

Implementability: Alternatives A2-GW3 and A2-GW4 would be more difficult to implement than would Alternatives A2-GW1 and A2-GW2 since they involve groundwater extraction and treatment. The treatment system components are demonstrated and commercially available.

Cost: The 30-year net present worth costs for the Area A2 groundwater alternatives are summarized below:

- Alternative A2-GW1: $476,700
- Alternative A2-GW2: $476,700
- Alternative A2-GW3: $796,000 (includes only O&M costs for Area A2)
- Alternative A2-GW4: $168,000 (includes only O&M costs for Area A2)

8.3.3 Comparison of Area B Groundwater Alternatives

A side-by-side comparison of the Area B groundwater alternatives, based on the seven evaluation criteria used in the previous sections, is presented in Table 8-7. A summary of the alternative comparison based on the seven criteria is provided in the following sections.

Overall Protection: Alternatives B-GW1 and B-GW2 would not contain or treat contaminated groundwater. Alternative B-GW3 would achieve protection of the water table and Yorktown aquifers for their beneficial uses through groundwater extraction and treatment.

Compliance with ARARs: Alternatives B-GW1 and B-GW2 would not treat or contain groundwater contaminated above federal MCLs. However, groundwater on-site and in the vicinity of the site currently is not used for drinking water purposes. Alternative B-GW3 would comply with these ARARs by containing and potentially restoring contaminated groundwater within the Yorktown Aquifer to federal MCLs. Groundwater within the water table aquifer would be contained and potentially restored to cleanup levels based on nonpotable use. Under Alternative B-GW3, treated groundwater and associated air emissions would comply with all local, state, and federal ARARs.

Long-term Effectiveness and Permanence: All alternatives currently provide on-site protection of human health since groundwater is not currently used on site. All alternatives, except Alternative B-GW1, would provide on-site protection of human health through institutional controls.

Under Alternatives B-GW1 and B-GW2, risks would exceed acceptable levels if the groundwater were to be used for potable use. Under Alternative B-GW3, risks associated with potable use of groundwater would be within acceptable levels following groundwater restoration. Thus, Alternative B-GW3 would ultimately provide the greatest degree of long-term effectiveness.

Reduction of Toxicity, Mobility, or Volume: Alternatives B-GW1 and B-GW2 would not reduce the toxicity, mobility, or volume of contaminants in the groundwater through treatment. Alternative B-GW3 would reduce the toxicity and volume of contaminants to the established cleanup goals through treatment and would reduce contaminant mobility through extraction.

Short-term Effectiveness: There would be no risks to human health or the environment associated with implementation of Alternatives B-GW1 and B-GW2. Under Alternative B-GW3, air emissions would be regularly monitored to ensure compliance with state and federal air quality standards.

Implementability: Alternative B-GW3 would be more difficult to implement than would Alternatives B-GW1 and B-GW2 since it involves groundwater extraction and treatment. The treatment system components are demonstrated and commercially available.

Cost: The 30-year net present worth costs for the Area B groundwater alternatives are summarized below:

- Alternative B-GW1: $476,700
- Alternative B-GW2: $476,700
- Alternative B-GW3: $842,500 (includes only O&M costs for Area B)

SECTION 8.0 TABLES

TABLE 8-1

SUMMARY OF EVALUATION CRITERIA

Threshold Criteria

- **Overall Protection of Human Health and Environment** - addresses whether or not an alternative provides adequate protection and describes how risks posed through each pathway are eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls.

- **Compliance with ARARs** - addresses whether or not an alternative will meet all of the applicable or relevant and appropriate requirements (ARARs) or other federal and state environmental statutes and/or provide grounds for invoking a waiver.

Primary Balancing Criteria

- **Long-Term Effectiveness and Permanence** - refers to the magnitude of residual risk and the ability of an alternative to maintain reliable protection of human health and the environment over time once cleanup goals have been met.

- **Reduction of Toxicity, Mobility, or Volume through Treatment** - is the anticipated performance of the treatment options that may be employed in an alternative.

- **Short-Term Effectiveness** - refers to the speed with which the alternative achieves protection, as well as the remedy's potential to create adverse impacts on human health and the environment during the construction and implementation period.

- **Implementability** - is the technical and administrative feasibility of an alternative, including the availability of materials and services needed to implement the chosen solution.

- **Cost**- includes capital and operation and maintenance costs, and for comparative purposes, net present worth values.

Modifying Criteria

- **USEPA/State Acceptance** - indicates whether, based on review of the RI and FS reports and the PRAP, the USEPA and state concur with, oppose, or have no comments on the preferred alternative.

- **Community Acceptance** - will be addressed in this Decision Document following a review of the public comments received on the RI and FS reports and the PRAP.

TABLE 8-2

COMPARISON OF AREA A SOIL ALTERNATIVES
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

ALTERNATIVE A-SO1 NO ACTION	ALTERNATIVE A-SO2 INSTITUTIONAL CONTROLS	ALTERNATIVE A-SO3 ASPHALT/GEOSYNTHETIC CAP OVER BRIG AREA(1)	ALTERNATIVE A-SO4 COMPOSITE CAP OVER HOT SPOT AREAS(1)	ALTERNATIVE A-SO5 DUAL PHASE VACUUM EXTRACTION OF HOT SPOT AREAS(1)	ALTERNATIVE A-SO6 THERMAL TREATMENT OF HOT SPOT AREAS(1)	ALTERNATIVE A-SO7 OFF-SITE DISPOSAL OF HOT SPOT AREAS(1)
OVERALL PROTECTION TO HUMAN HEALTH AND THE ENVIRONMENT						
No unacceptable risks from surface soils for current land use. Marginal risk from surface soils for future residential use. Potential risks from buried wastes. No additional protection from direct contact with potential soil contamination. No additional protection of groundwater.	No unacceptable risks from surface soils for current land use. Marginal risk from surface soils for future residential use. Potential risks from buried wastes. Protection from direct contact provided by institutional controls. No additional protection of groundwater.	No unacceptable risks from surface soils for current land use. Marginal risk from surface soils for future residential use. Potential risks from buried wastes. Protection from direct contact provided by institutional controls and cap. Partial protection of groundwater provided by cap over Brig area.	No unacceptable risks from surface soils for current land use. Marginal risk from surface soils for future residential use. Potential risks from buried wastes. Protection from direct contact provided by institutional controls and cap. Partial protection of groundwater provided by cap over hot spot area(s).	No unacceptable risks from surface soils for current land use. Marginal risk from surface soils for future residential use. Potential risks from buried wastes. Protection from direct contact provided by institutional controls. Protection of groundwater provided by in situ treatment of source area(s).	No unacceptable risks from surface soils for current land use. Marginal risk from surface soils for future residential use. Potential risks from buried wastes. Protection from direct contact provided by institutional controls. Protection of groundwater provided by ex situ treatment of source(s).	No unacceptable risks from surface soils for current land use. Marginal risk from surface soils for future residential use. Potential risks from buried wastes. Protection from direct contact provided by institutional controls. Protection of groundwater by off-site disposal of source area(s).
COMPLIANCE WITH ARARS						
No contaminant-, location-, or action-specific ARARs.	No contaminant-, location- or action-specific ARARs.	No contaminant-specific ARARs. Cap designed in accordance with RCRA and state solid waste regulations.	No contaminant-specific ARARs. Cap designed in accordance with RCRA and state hazardous waste regulations.	No contaminant-specific ARARs. Air emissions would be treated to comply with state air pollution standards. Any hazardous materials would be handled/ disposed in accordance with RCRA and state hazardous waste regulations.	No contaminant-specific ARARs. Air emissions would be treated to comply with state air pollution standards. Any hazardous materials would be handled/disposed in accordance with RCRA and state hazardous waste regulations.	No contaminant-specific ARARs. Air emissions would be treated to comply with state air pollution standards. Any hazardous materials would be handled/disposed in accordance with RCRA and state hazardous waste regulations.
LONG-TERM EFFECTIVENESS AND PERMANENCE						
No remedial action would be taken. No reduction in risk levels; however, risks are acceptable under current use, and site is not used for residential use. No additional protection of groundwater.	Institutional actions would administratively limit future site use to nonresidential use. Risks are acceptable under current use, and site is not used for residential use. Maintenance of landfill soil cover effective in limiting surface water infiltration and erosion.	Institutional actions would administratively restrict access to site and limit future site use to nonresidential use. Risks are acceptable under current use, and site is not used for residential use. Partial long-term protection of groundwater provided by cap over potential source areas in vicinity of Brig.	Institutional actions would administratively restrict access to site and limit future site use to nonresidential use. Risks are acceptable under current use, and site is not used for residential use. Partial long-term protection of groundwater provided by cap over hot spot area(s).	Institutional actions would administratively restrict access to site and limit future site use to nonresidential use. Risks are acceptable under current use, and site is not used for residential use. Permanent long-term protection of groundwater provided by in situ treatment.	Institutional actions would administratively restrict access to site and limit future site use to nonresidential use. Risks are acceptable under current use, and site is not used for residential use. Permanent long-term protection of groundwater provided by ex situ treatment.	Institutional actions would administratively restrict access to site and limit future site use to nonresidential use. Risks are acceptable under current use, and site is not used for residential use. Permanent long-term protection of groundwater provided by off-site disposal.
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME (TMV) THROUGH TREATMENT						
No reduction in TMV through treatment. Possible reduction in TMV through natural processes.	No reduction in TMV through treatment. Possible reduction in TMV through natural processes.	No reduction in TMV through treatment. Possible reduction in TMV through natural processes. Partial reduction in mobility through capping.	No reduction in TMV through treatment. Possible reduction in TMV through natural processes. Partial reduction in mobility through capping.	Reduction in TMV through in situ vacuum extraction/treatment. Effective removal of VOCs, partial removal of SVOCs.	Reduction in TMV through ex situ thermal treatment. Very effective removal of VOCs and effective removal of SVOCs.	No reduction in TMV through treatment. Reduction in mobility via disposal in secure off-site landfill.

TABLE 8-2 (Continued)

COMPARISON OF AREA A SOIL ALTERNATIVES
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

ALTERNATIVE A-SO1 NO ACTION	ALTERNATIVE A-SO2 INSTITUTIONAL CONTROLS	ALTERNATIVE A-SO3 ASPHALT/GEOSYNTHETIC CAP OVER BRIG AREA[(1)]	ALTERNATIVE A-SO4 COMPOSITE CAP OVER HOT SPOT AREAS[(1)]	ALTERNATIVE A-SO5 DUAL PHASE VACUUM EXTRACTION OF HOT SPOT AREAS[(1)]	ALTERNATIVE A-SO6 THERMAL TREATMENT OF HOT SPOT AREAS[(1)]	ALTERNATIVE A-S07 OFF-SITE DISPOSAL OF HOT SPOT AREAS[(1)]
SHORT-TERM EFFECTIVENESS						
No risk to human health or environment during implementation.	No risk to human health or environment during implementation.	No risk to human health or environment during implementation.	No risk to human health or environment during implementation.	Potential risks to human health and environment during operation would be controlled by air emission treatment/ monitoring. Several years required to achieve cleanup levels.	Potential risks to human health and environment during operation would be controlled by air emission treatment/ monitoring. Approx. 6 months required to complete remediation.	Potential risks to human health and environment during excavation would be controlled by dust controls. Approx. 2 months required to complete remediation.
IMPLEMENTABILITY						
Readily implementable.	Straight-forward installation of fencing. Periodic inspection and maintenance of fenced required. Legal/administrative requirements for institutional controls.	Legal/administrative requirements for institutional controls. Capping technologies demonstrated and commercially available. Periodic inspection and maintenance of cap required.	Legal administrative requirements for institutional controls. Capping technologies demonstrated and commercially available. Periodic inspection and maintenance of cap required.	Administrative requirements for institutional controls. Technologies demonstrated and commercially available. Approx. 5-year operation of treatment system.	Administrative requirements for institutional controls. Technologies demonstrated and commercially available. Trial runs may be required. Potential public opposition. Approx. 6-month operation of treatment system.	Administrative requirements for institutional controls. Technologies demonstrated and commercially available.
COST						
Capital: $0 O&M: $20,000 (every 5 years) NPW: $55,600	Capital: $0 O&M: $17,557 (annually); $20,000 (every 5 years) NPW: $325,500	Capital: $927,200 O&M: $17,557 (annually); $95,653 (every 5 years) NPW: $1,877,900	Capital: $465,300 O&M: $19,395 (annually); $39,395 (every 5 years) NPW: $819,100	Capital: $490,700 O&M: $108,066 (years 1-4) $139,022 (year 5) $17,557 (years 6-30) NPW: $1,216,700	Capital: $6,141,500 O&M: $17,557 (annually); $37,557 (every 5 years) NPW: $6,467,100	Capital: $9,867,900 O&M: $17,557 (annually); $37,557 (every 5 years) NPW: $10,193,500

[(1)] Alternative includes Institutional Controls
O&M: Operation and Maintenance
NPW: 30-year Net Present Worth

TABLE 8-3

COMPARISON OF AREA B SOIL ALTERNATIVES
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

ALTERNATIVE B-SO1 NO ACTION	ALTERNATIVE B-SO2 INSTITUTIONAL CONTROLS
OVERALL PROTECTION TO HUMAN HEALTH AND THE ENVIRONMENT	
No unacceptable risks from surface soils for current land uses, marginal risks for future residential use. Provides no additional protection from direct contact, no additional protection of groundwater. However, the removal action of sources at Area B will provide protection.	No unacceptable risks from surface soils for current land uses, marginal risks for future residential use. Provides some additional protection from direct contact by institutional controls, no additional protection of groundwater. However, the removal action of sources at Area B will provide protection.
COMPLIANCE WITH ARARS	
No contaminant-, location-, or action-specific ARARs.	No contaminant-, location- or action-specific ARARs.
LONG-TERM EFFECTIVENESS AND PERMANENCE	
No remedial action; however, the removal action will provide effective and permanent source removal.	Institutional controls would limit future land use to non-residential. The removal action will provide effective and permanent source control.
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME (TMV) THROUGH TREATMENT	
No reduction in TMV through treatment. Possible reduction in TMV through natural processes.	No reduction in TMV through treatment. Possible reduction in TMV through natural processes.
SHORT-TERM EFFECTIVENESS	
No risks to human health or environment during implementation.	No risks to human health or environment during implementation.
IMPLEMENTABILITY	
No action; therefore, no implementability concerns.	Periodic inspection and maintenance of fenced required. Legal/administrative requirements for institutional controls.
COST	
Capital: $0 O&M: $20,000 (every 5 years) NPW: $55,600	Capital: $0 O&M: $600 (annually); $20,000 (every 5 years) NPW: $63,200

O&M: Operation and Maintenance
NPW: 30-year Net Present Worth

TABLE 8-4

COMPARISON OF SURFACE WATER/SEDIMENT ALTERNATIVES
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

ALTERNATIVE SD-1 NO ACTION	ALTERNATIVE SD-2 INSTITUTIONAL CONTROLS WITH MONITORING
OVERALL PROTECTION TO HUMAN HEALTH AND THE ENVIRONMENT	
No unacceptable human health risks associated with exposure to Area A or Area B surface water/sediment. No unacceptable risks associated with elementary school in Area B. Marginal risks for future residential use. Low levels of contaminants. Migration of contaminants to groundwater not considered to be a pathway. Provides no additional protection.	No unacceptable human health risks associated with exposure to Area A or Area B surface water/sediment. No unacceptable risks associated with elementary school in Area B. Marginal risks for future residential use. Low levels of contaminants. Migration of contaminants to groundwater not considered to be a pathway. Provides some additional protection through institutional controls.
COMPLIANCE WITH ARARS	
Minor exceedances of federal and state standards for surface water. No action- or location-specific ARARs.	Minor exceedances of federal and state standards for surface water. No action- or location-specific ARARs.
LONG-TERM EFFECTIVENESS AND PERMANENCE	
No remedial action -- risks same as in baseline risk assessment. However, source control actions in Areas A and B are expected to improve surface water/sediment quality over time.	Institutional controls would limit future land use to non-residential. Monitoring would provide information to track contaminant levels in these media.
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME (TMV) THROUGH TREATMENT	
No reduction in TMV through treatment. Possible reduction in TMV through natural processes.	No reduction in TMV through treatment. Possible reduction in TMV through natural processes.
SHORT-TERM EFFECTIVENESS	
No risks to human health during implementation.	No risks to human health during implementation.
IMPLEMENTABILITY	
No action; therefore, no implementability concerns.	Legal/administrative requirements for institutional controls. Monitoring easily implemented.
COST	
Capital: $0 O&M: $20,000 (every 5 years) NPW: $55,600	Capital: $0 O&M: $50,477 (annually); $70,477 (every 5 years) NPW: $831,600

O&M: Operation and Maintenance
NPW: 30-year Net Present Worth

TABLE 8-5

COMPARISON OF AREA A1 GROUNDWATER ALTERNATIVES
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

ALTERNATIVE A1-GW1 NO ACTION[1]	ALTERNATIVE A1-GW2 INSTITUTIONAL CONTROLS[1]	ALTERNATIVE A1-GW3 PROTECTION OF YORKTOWN AQUIFER FOR BENEFICIAL USE THROUGH EXTRACTION AND TREATMENT[2]
OVERALL PROTECTION TO HUMAN HEALTH AND THE ENVIRONMENT		
Would not contain or treat contaminated groundwater. Groundwater on site not currently used for any purpose. Off-site shallow groundwater used for nonpotable residential use. Off-site deep groundwater used for industrial use. Deep groundwater contamination would continue to migrate off site. Shallow groundwater contamination does not appear to be migrating off site.	Would not contain or treat contaminated groundwater. Groundwater on site not currently used for any purpose. Off-site shallow groundwater used for nonpotable residential use. Off-site deep groundwater used for industrial use. Deep groundwater contamination would continue to migrate off site. Shallow groundwater contamination does not appear to be migrating off site. If necessary in the future, institutional controls would prevent potable use and limit nonpotable use of contaminated groundwater.	Would contain and treat contaminated groundwater in the Yorktown Aquifer to established cleanup goals. Groundwater on site not currently used for any purpose. Off-site shallow groundwater used for nonpotable residential use. Off-site deep groundwater used for industrial use. Shallow groundwater contamination does not appear to be migrating off site. If necessary in the future, institutional controls would prevent or limit use of contaminated groundwater.
COMPLIANCE WITH ARARs		
Shallow and deep contaminated groundwater exceeds federal MCLs. Both aquifers, however, currently are not used for drinking water purposes.	Shallow and deep contaminated groundwater exceeds federal MCLs. Both aquifers, however, currently are not used for drinking water purposes.	Both aquifers currently are not used for drinking water purposes. Intent of alternative is to restore Yorktown Aquifer to federal MCLs. Extracted groundwater and air emissions would comply with all local, state, and federal ARARs.
LONG-TERM EFFECTIVENESS AND PERMANENCE		
Under current conditions, risks would exceed acceptable levels if shallow and deep aquifers were used for potable use on site. Currently no unacceptable risks associated with off-site nonpotable use of groundwater. Periodic groundwater monitoring would effectively track potential contaminant migration.	Under current conditions, risks would exceed acceptable levels if shallow and deep aquifers were used for potable use on site. Currently no unacceptable risks associated with off-site nonpotable use of groundwater. Potential future risks would be mitigated through institutional controls. Periodic groundwater monitoring would effectively track potential contaminant migration.	Under current conditions, risks would exceed acceptable levels if shallow and deep aquifers were used for potable use on site. Currently no unacceptable risks associated with off-site nonpotable use of groundwater. Extraction system should prevent off-site migration of contamination above cleanup goals. Potential future risks would be mitigated through institutional controls. Periodic groundwater monitoring would effectively track potential contaminant migration.

TABLE 8-5 (CONTINUED)

COMPARISON OF AREA A1 GROUNDWATER ALTERNATIVES
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

ALTERNATIVE A1-GW1 NO ACTION[1]	ALTERNATIVE A1-GW2 INSTITUTIONAL CONTROLS[1]	ALTERNATIVE A1-GW3 PROTECTION OF YORKTOWN AQUIFER FOR BENEFICIAL USE THROUGH EXTRACTION AND TREATMENT[2]
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME (TMV) THROUGH TREATMENT		
No reduction in TMV through treatment. Possible reduction in toxicity over time through dilution and dispersion.	No reduction in TMV through treatment. Possible reduction in toxicity over time through dilution and dispersion.	Toxicity and volume reduced to established cleanup goals through extraction and treatment. Mobility reduced through extraction.
SHORT-TERM EFFECTIVENESS		
No risk to human health or environment during implementation.	No risk to human health or environment during implementation.	Air emissions from treatment system would be monitored to protect human health and the environment.
IMPLEMENTABILITY		
Groundwater monitoring could be readily implemented.	Groundwater monitoring could be readily implemented.	Treatment system components are demonstrated and commercially available.
COST		
Capital: $0 O&M: $38,600 (years 1-10) $19,600 (years 11-20) $10,100 (years 21-30) $20,000 (every 5 years) NPW: $476,700	Capital: $0 O&M: $38,600 (years 1-10) $19,600 (years 11-20) $10,100 (years 21-30) $20,000 (every 5 years) NPW: $476,700	Capital: $6,108,500 O&M: $187,300 (yrs 1-10) $168,300 (yrs 11-20) $158,800 (yrs 21-30) $20,000 (every 5 yrs) NPW: $8,870,200

[1] Alternative includes groundwater monitoring.
[2] Alternative cost includes extraction and treatment system capital cost.
O&M: Operation and maintenance.
NPW: Net present worth.

TABLE 8-6

COMPARISON OF AREA A2 GROUNDWATER ALTERNATIVES
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

ALTERNATIVE A2-GW1 NO ACTION(1)	ALTERNATIVE A2-GW2 INSTITUTIONAL CONTROLS(1)	ALTERNATIVES A2-GW3 AND A2-GW4 PROTECTION OF WATER TABLE AND YORKTOWN AQUIFERS FOR BENEFICIAL USES THROUGH EXTRACTION AND TREATMENT(2)
OVERALL PROTECTION TO HUMAN HEALTH AND THE ENVIRONMENT		
Would not contain or treat contaminated groundwater. Groundwater on site not currently used for any purpose. Off-site shallow groundwater used for nonpotable residential use. Off-site deep groundwater used for industrial use. Deep groundwater contamination may continue to migrate off site. Shallow groundwater contamination does not appear to be migrating off site.	Would not contain or treat contaminated groundwater. Groundwater on site not currently used for any purpose. Off-site shallow groundwater used for nonpotable residential use. Off-site deep groundwater used for industrial use. Deep groundwater contamination may continue to migrate off site. Shallow groundwater contamination does not appear to be migrating off site. If necessary in the future, institutional controls would prevent potable use and limit nonpotable use of contaminated groundwater.	Would contain and treat contaminated groundwater to established cleanup goals. Groundwater on site not currently used for any purpose. Off-site shallow groundwater used for nonpotable residential use. Off-site deep groundwater used for industrial use. Shallow groundwater contamination does not appear to be migrating off site. If necessary in the future, institutional controls would prevent or limit use of contaminated groundwater.
COMPLIANCE WITH ARARs		
Shallow and deep contaminated groundwater exceeds federal MCLs. Both aquifers, however, currently are not used for drinking water purposes.	Shallow and deep contaminated groundwater exceeds federal MCLs. Both aquifers, however, currently are not used for drinking water purposes.	Both aquifers currently are not used for drinking water purposes. Intent of alternative is to restore the water table and Yorktown Aquifers to their respective cleanup goals. Extracted groundwater and air emissions would comply with all local, state, and federal ARARs.

TABLE 8-6 (Continued)

COMPARISON OF AREA A2 GROUNDWATER ALTERNATIVES
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

ALTERNATIVE A2-GW1 NO ACTION(1)	ALTERNATIVE A2-GW2 INSTITUTIONAL CONTROLS(1)	ALTERNATIVES A2-GW3 AND A2-GW4 PROTECTION OF WATER TABLE AND YORKTOWN AQUIFERS FOR BENEFICIAL USES THROUGH EXTRACTION AND TREATMENT(2)
LONG-TERM EFFECTIVENESS AND PERMANENCE		
Under current conditions, risks would exceed acceptable levels if shallow and deep aquifers were used for potable use on site. Currently no unacceptable risks associated with off-site nonpotable use of groundwater. Periodic groundwater monitoring would effectively track potential contaminant migration.	Under current conditions, risks would exceed acceptable levels if shallow and deep aquifers were used for potable use on site. Currently no unacceptable risks associated with off-site nonpotable use of groundwater. Potential future risks would be mitigated through institutional controls. Periodic groundwater monitoring would effectively track potential contaminant migration.	Under current conditions, risks would exceed acceptable levels if shallow and deep aquifers were used for potable use on site. Currently no unacceptable risks associated with off-site nonpotable use of groundwater. Extraction system should prevent off-site migration of contamination above cleanup goals. Potential future risks would be mitigated through institutional controls. Periodic groundwater monitoring would effectively track potential contaminant migration.
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME (TMV) THROUGH TREATMENT		
No reduction in TMV through treatment. Possible reduction in toxicity over time through dilution and dispersion.	No reduction in TMV through treatment. Possible reduction in toxicity over time through dilution and dispersion.	Toxicity and volume reduced to established cleanup goals through extraction and treatment. Mobility reduced through extraction.
SHORT-TERM EFFECTIVENESS		
No risk to human health or environment during implementation.	No risk to human health or environment during implementation.	Air emissions from treatment system would be monitored to protect human health and the environment.
IMPLEMENTABILITY		
Groundwater monitoring could be readily implemented.	Groundwater monitoring could be readily implemented.	Treatment system components are demonstrated and commercially available.

TABLE 8-6 (Continued)

COMPARISON OF AREA A2 GROUNDWATER ALTERNATIVES
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

ALTERNATIVE A2-GW1 NO ACTION[1]	ALTERNATIVE A2-GW2 INSTITUTIONAL CONTROLS[1]	ALTERNATIVES A2-GW3 AND A2-GW4 PROTECTION OF WATER TABLE AND YORKTOWN AQUIFERS FOR BENEFICIAL USES THROUGH EXTRACTION AND TREATMENT[2]
COST		
Capital: $0 O&M: $38,600 (years 1-10) $19,600 (years 11-20) $10,100 (years 21-30) $20,000 (every 5 years) NPW: $476,700	Capital: $0 O&M: $38,600 (years 1-10) $19,600 (years 11-20) $10,100 (years 21-30) $20,000 (every 5 years) NPW: $476,700	A2-GW3 / A2-GW4 Capital: $0 / $0 O&M: $59,400 / $8,900 (yrs 1-10) $40,400 / $6,200 (yrs 11-20) $30,900 / $4,900 (yrs 21-30) $20,000 / $20,000 (every 5 yrs) NPW: $796,000 / $168,000

[1] Alternative includes groundwater monitoring.
[2] Alternative cost includes only additional O&M costs for Area A2 groundwater treatment.
O&M: Operation and maintenance.
NPW: Net present worth.

TABLE 8-7

COMPARISON OF AREA B GROUNDWATER ALTERNATIVES
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

ALTERNATIVE B-GW1 NO ACTION(1)	ALTERNATIVE B-GW2 INSTITUTIONAL CONTROLS(1)	ALTERNATIVE B-GW3 PROTECTION OF WATER TABLE AND YORKTOWN AQUIFERS FOR BENEFICIAL USES THROUGH EXTRACTION AND TREATMENT(2)
OVERALL PROTECTION TO HUMAN HEALTH AND THE ENVIRONMENT		
Would not contain or treat contaminated groundwater, however, groundwater on site and immediately downgradient of contamination is not currently used for any purpose.	Would not contain or treat contaminated groundwater, however, groundwater on site and immediately downgradient of contamination is not currently used for any purpose. Institutional controls would prevent future potable use and limit nonpotable use of contaminated groundwater.	Would contain and treat contaminated groundwater to established cleanup goals. Contamination below cleanup goals would continue to migrate off site. Groundwater on site and immediately downgradient of contamination is not currently used for any purpose. If necessary in the future, institutional controls would prevent or limit use of contaminated groundwater.
COMPLIANCE WITH ARARs		
Shallow and deep contaminated groundwater exceeds federal MCLs. Both aquifers, however, currently are not used for drinking water purposes.	Shallow and deep contaminated groundwater exceeds federal MCLs. Both aquifers, however, currently are not used for drinking water purposes.	Both aquifers currently are not used for drinking water purposes. Intent of alternative is to restore the water table and Yorktown Aquifers to their respective cleanup goals. Extracted groundwater and air emissions would comply with all local, state, and federal ARARs.
LONG-TERM EFFECTIVENESS AND PERMANENCE		
Under current conditions, risks would exceed acceptable levels if shallow or deep aquifers were used for potable use on site. Periodic groundwater monitoring would effectively track potential contaminant migration.	Under current conditions, risks would exceed acceptable levels if shallow or deep aquifers were used for potable use on site. Potential future risks would be mitigated through institutional controls. Periodic groundwater monitoring would effectively track potential contaminant migration.	Under current conditions, risks would exceed acceptable levels if shallow and deep aquifers were used for potable use on site. Extraction system should prevent off-site migration of contamination above cleanup goals. Potential future risks would be mitigated through institutional controls. Periodic groundwater monitoring would effectively track potential contaminant migration.

TABLE 8-7 (Continued)

COMPARISON OF AREA B GROUNDWATER ALTERNATIVES
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

ALTERNATIVE B-GW1 NO ACTION(1)	ALTERNATIVE B-GW2 INSTITUTIONAL CONTROLS(1)	ALTERNATIVE B-GW3 PROTECTION OF WATER TABLE AND YORKTOWN AQUIFERS FOR BENEFICIAL USES THROUGH EXTRACTION AND TREATMENT(2)
REDUCTION OF TOXICITY, MOBILITY, OR VOLUME (TMV) THROUGH TREATMENT		
No reduction in TMV through treatment. Possible reduction in toxicity over time through dilution and dispersion.	No reduction in TMV through treatment. Possible reduction in toxicity over time through dilution and dispersion.	Toxicity and volume reduced to established cleanup goals through extraction and treatment. Mobility reduced through extraction.
SHORT-TERM EFFECTIVENESS		
No risk to human health or environment during implementation.	No risk to human health or environment during implementation.	Air emissions from treatment system would be treated and monitored to protect human health and the environment.
IMPLEMENTABILITY		
Groundwater monitoring could be readily implemented.	Groundwater monitoring could be readily implemented.	Treatment system components are demonstrated and commercially available.
COST		
Capital: $0 O&M: $38,600 (years 1-10) $19,600 (years 11-20) $10,1000 (years 21-30) $20,000 (every 5 years) NPW: $476,700	Capital: $0 O&M: $38,600 (years 1-10) $19,600 (years 11-20) $10,100 (years 21-30) $20,000 (every 5 years) NPW: $476,700	Capital: $0 O&M: $62,400 (years 1-10) $43,400 (years 11-20) $34,000 (years 21-30) $20,000 (every 5 years) NPW: $842,500

(1) Alternative includes groundwater monitoring.
(2) Alternative cost includes only additional O&M costs for Area B groundwater treatment.
O&M: Operation and maintenance.
NPW: Net present worth.

9.0 THE SELECTED REMEDY

9.1 Site Remediation Goals

Based on RI findings and the results of the baseline risk assessment, three media of concern have been identified at the Camp Allen Landfill Site as follows:

- Soils
- Surface Water/Sediments
- Groundwater

Site remediation goals were developed for each medium of concern considering the contaminants of concern, potential receptors, and exposure scenarios. Given the removal action at Area B, site remediation goals differ slightly for soil between Areas A and B of the Camp Allen Landfill Site. Site remediation goals for each area are listed as follows:

- Soil
  - Prevent exposure to subsurface soil and debris.
  - Minimize migration of contaminants to groundwater and surface water (Area A only since removal action at Area B has been successfully implemented).

- Surface Water/Sediment
  - Prevent exposure to potential contaminants in surface water and sediments.
  - Address indirectly through the development of soil and groundwater alternatives.

- Groundwater
  - Prevent exposure to contaminated groundwater.
  - Prevent further migration of contaminated groundwater.
  - Restore contaminated aquifers.

9.2 Cleanup Goal Development

The three media of concern that have been identified at the site are: soils, groundwater and surface water/sediments. Cleanup goals are developed in the following sections for soils and groundwater. Cleanup goals have not been established for surface water/sediments because removal and/or treatment alternatives were not evaluated for site surface water/sediments, as discussed in Section 7.2.

9.2.1 Soil Cleanup Goals

Soil analytical data obtained during the Camp Allen Landfill pre-design investigation indicate the presence of VOCs in subsurface soils in Areas A1 and A2. Under the influence of infiltrating precipitation, these VOCs may migrate through the unsaturated zone soils to the water table aquifer. Thus, under current conditions, the contaminated subsurface soils in Areas A1 and A2 could potentially act as sources of continuing contamination to underlying groundwater. The objective of soil cleanup goal development was to determine subsurface soil cleanup goals based on the potential for the VOCs to migrate (i.e., leach) to the water table aquifer in Areas A1 and A2 at the Camp Allen Landfill.

A spreadsheet-based transport model described by Summers was developed to determine the potential soil cleanup goals. The Summers Model is a one-dimensional advective transport model that estimates the potential contaminant concentration in leachate (emanating from the source area) at the top of the water table aquifer. The general input data for the spreadsheet model include contaminant characteristics, unsaturated zone characteristics, hydrogeological properties of the water table aquifer, and annual precipitation data. Site-specific data were obtained from the pre-design investigation as well as from previous field investigations. A more detailed description of the Summers Model, as well as the specific modeling inputs and their sources used in the spreadsheet calculation of soil cleanup goals, are provided in the Final Camp Allen Landfill Feasibility Study.

The soil cleanup goals developed using the Summers Model for the contaminants of concern in Areas A1 and A2 are provided in Table 9-1. The soil cleanup goals shown in Table 9-1 were based on attainment of federal MCLs in shallow groundwater immediately below the source area as a conservative measure in order to protect the underlying Yorktown Aquifer to its potential future beneficial use (i.e., drinking water supply). Since the MCLs for the contaminants of concern are less than the Federal Ambient Water Quality Criteria and Virginia Water Quality Standards, soil cleanup goals are also protective of surface water.

The soil cleanup goals were used to estimate remediation areas and the volume of contaminated soil in Area A. It should be noted that, since Area A is a landfill, the primary remediation goal for the soils is groundwater protection rather than soil cleanup. Therefore, achievement of this goal will be determined through evaluation of actual environmental monitoring results (i.e., via on-going monitoring of contaminant levels in groundwater), and will not necessarily be based on attainment of the developed soil cleanup goals since they represent theoretical values calculated through modeling.

9.2.2 Groundwater Cleanup Goals

Cleanup goals for each aquifer have been developed based on the potential beneficial use of the aquifer. For the Yorktown Aquifer, the groundwater cleanup goals were based on attainment of federal MCLs in order to protect the aquifer for its potential future beneficial use (i.e., potential future drinking water supply). The cleanup goals for the Yorktown Aquifer are shown in Table 9-2.

It is recognized that MCLs may be impossible to achieve since it has been demonstrated that groundwater contaminant levels typically reach asymptotic levels, which may exceed MCLs. Performance curves will be periodically (e.g., annually) developed to monitor groundwater contaminant levels. If the performance curves indicate that asymptotic levels have been reached that exceed MCLs for some contaminants, then the cleanup goals may be reevaluated at that time.

Unlike the Yorktown Aquifer, the beneficial use of the water table aquifer is nonpotable use. Therefore, nonpotable use cleanup goals were developed for the water table aquifer, which were based on a 1×10^{-6} cancer risk level and a hazard quotient of 1.0 for children and the exposure pathways of incidental ingestion and dermal absorption of contaminants during outdoor activities, such as car washing and lawn watering. Cleanup goals for the water table aquifer are also presented in Table 9-2.

As a point of comparison, Federal Ambient Water Quality Criteria (AWQC) were included in Table 9-2 (there are no State AWQC for contaminants of potential concern). These surface water criteria would apply to groundwater as it discharges into surface water. The Yorktown Aquifer cleanup goals (based on Federal MCLs) are less than the Federal AWQC for all contaminants. The water table aquifer cleanup goals are less than the Federal AWQC for all contaminants except toluene. However, the maximum concentration of toluene detected in groundwater (567 μg/L) is less than the Federal AWQC for toluene (5,000 μg/L). Therefore, these groundwater cleanup levels are also protective of surface water.

9.3 Selected Remedy Description

The selected remedy for each medium of concern for Areas A and B is identified below:

Area A1 Soil

Alternative A-SO5: In Situ Treatment by Dual Phase Vacuum Extraction with Institutional Controls

Area A2 Soil

Alternative A-SO2: Institutional Controls

Area B Soil

Alternative B-SO2: Institutional Controls

Surface Water/Sediment (Areas A and B)

Alternative SD-2: Institutional Controls with Monitoring

Area A1 Groundwater

Alternative A1-GW3: Protection of the Yorktown Aquifer for Beneficial Use Through Extraction and Treatment, Institutional Controls, and Monitoring

Area A2 Shallow Groundwater (Water Table Aquifer)

Alternative A2-GW4: Protection of the Water Table Aquifer for Beneficial Use Through Extraction and Treatment, Institutional Controls, and Monitoring

Area A2 Deep Groundwater (Yorktown Aquifer)

Alternative A2-GW2: Institutional Controls with Monitoring.

Area B Groundwater

Alternative B-GW3: Protection of the Water Table and Yorktown Aquifers for Beneficial Use Through Extraction and Treatment, Institutional Controls, and Monitoring

9.3.1 Rationale for Selected Remedies

Based on available information and the current understanding of site conditions, each alternative appears to provide the best balance of trade-offs with respect to the nine CERCLA evaluation criteria. In addition, the selected alternatives are anticipated to meet the following statutory requirements:

- Protection of human health and the environment
- Compliance with ARARs (or justification of a waiver)
- Cost-effectiveness
- Utilization of permanent solutions and alternative treatment or resource recovery technologies to the maximum extent practicable

The proposed response actions (or selected remedies) identified herein address all contaminated media of concern at the site and comprise the overall cleanup strategy for the site. Contaminated media addressed by the selected remedies include contaminated soil, surface water/sediment, and groundwater in Areas A and B. The selected remedies for the various media are briefly described below.

Soil Alternatives

Area A1

The preferred alternative for contaminated soil in Area A1 is Alternative A-SO5, In Situ Treatment by Dual Phase Vacuum Extraction (DPVE) with institutional controls. The DPVE system offers a significant advantage over other treatment alternatives in that it is able to extract both soil and shallow groundwater (water table aquifer) contamination with a single system. This benefit is especially valuable since it has been shown that the conventional pump and treat method would not be feasible for remediation of the water table aquifer in Area A1 due to its very low hydraulic conductivity. The groundwater extracted by the DPVE system would be pumped to the proposed on-site treatment plant for contaminated groundwater, which would be constructed as part of Alternatives A1-GW3 and B-GW3. Institutional controls would include maintenance of the existing fencing and soil cover in Area A1 and deed restrictions to limit the area to non-residential land use.

Area A2

The preferred alternative for Area A2 soils is A-SO2 - Institutional Controls. In contrast to Area A1, the DPVE pilot test performed in Area A2 yielded no identifiable contaminants in either the extracted groundwater or soil vapors, indicating that the extent of soil contamination in Area A2 is very limited. The test results also showed that the DPVE technology is not well suited for the shallow groundwater in Area A2, and that conventional submersible pumps are more appropriate for this area. Any contamination that may migrate from the soil to the shallow groundwater would be captured by the shallow groundwater extraction system proposed for Area A2. Similarly to Area A1, institutional controls would include maintenance of the existing fencing and soil cover in Area A2 and deed restrictions to limit the area to non-residential land use.

Area B

Since the primary source of groundwater contamination in Area B appeared to be concentrated in a relatively small volume of contaminated soil, a removal action was performed for the Area B contaminated soil. The removal action involved excavation of contaminated soil and debris in hot spot areas within Area B and off-site disposal of the excavated material at a RCRA-permitted hazardous waste management facility (landfill or incinerator). Since it is expected that this removal action has permanently removed the primary sources of contamination in Area B, the preferred alternative for Area B soils is Alternative B-SO2, Institutional Controls (fence maintenance and deed restrictions).

Surface Water/Sediment Alternative

The preferred alternative for surface water/sediment in Areas A and B is Alternative SD-2, Institutional Controls and Monitoring. The proposed remediation of the soil and groundwater in the Camp Allen Landfill Area is expected to result in a decrease in contaminant levels in surface water/sediment over time. Therefore, a post-remediation surface water/sediment monitoring program would be used to track trends in contamination levels over time in these media in the surrounding drainage channels. Additional sampling/analysis of surface water/sediment is proposed in the immediate future to establish baseline conditions of surface water/sediment in the vicinity of the Camp Allen Landfill Site for the proposed monitoring program.

Groundwater Alternatives

<u>Area A1</u>

The preferred alternative for groundwater in Area A1 is Alternative A1-GW3, Protection of the Yorktown Aquifer for Beneficial use Through Extraction and Treatment, Institutional Controls, and Monitoring. The water table aquifer in Area A1 will be addressed by the DPVE system that is proposed for Area A1 soils. Although there are no downgradient residential receptors for groundwater in this area, extraction and treatment of groundwater in the Yorktown Aquifer is recommended in Area A1, since the contaminant plume could migrate off of Navy property in this area. Groundwater in the Yorktown Aquifer would be extracted through a series of mid-depth (approximately 65 feet) pumping wells and would be pumped to an on-site treatment system. The treatment system, which would include metals removal via clarification/filtration, and removal of volatile organics via air stripping and carbon adsorption, would be sized to accommodate groundwater flows from Areas A1, A2, and B. A groundwater monitoring program would be implemented to assess trends in groundwater quality over time and to evaluate the effectiveness of the groundwater extraction and treatment system. Additionally, deed restrictions would be implemented to limit the area to non-residential land uses.

Area A2

The preferred alternative for the water table aquifer in Area A2 is A2-GW4 - Protection of the Water Table Aquifer for Beneficial Use through Extraction and Treatment, Institutional Controls, and Monitoring. This alternative was not included in the Feasibility Study because shallow groundwater remediation was addressed by the DPVE alternative developed for Area A2 soils. However, results of the DPVE pilot test indicate that the DPVE technology is not well-suited for the shallow groundwater in Area A2, and that conventional submersible pumps are more appropriate for this area. Therefore, Alternative A2-GW4 is proposed to contain shallow groundwater contamination in Area A2, which could migrate horizontally, or vertically to the Yorktown Aquifer. Implementation of this alternative would be very similar to Alternatives A1-GW3 and B-GW3. Groundwater in the water table aquifer would be extracted through shallow extraction wells (approximately 25 feet deep). Extracted groundwater would be pumped to the on-site groundwater treatment system proposed for Alternatives A1-GW3 and B-GW3.

At this time, the preferred alternative for the Yorktown Aquifer in Area A2 is Alternative A2-GW2, Institutional Controls with Monitoring. Since there are no receptors for groundwater immediately downgradient of Area A2, and the contaminant plume is not expected to migrate off Navy property in this area, extraction and treatment of groundwater in the Yorktown Aquifer is not recommended in Area A2. Since the water table aquifer within Area A2 will be remediated under Alternative A2-GW4, contaminant levels in groundwater in the Yorktown Aquifer may gradually decrease through dilution and natural attenuation. A groundwater monitoring program would be implemented to assess trends in groundwater quality over time. As previously noted, the on-site treatment system would be sized to treat flows from Areas A1, A2 and B. In the event that extraction and treatment of the Yorktown Aquifer in Area A2 becomes necessary, treatment capacity would be available. Additionally, deed restrictions would be implemented to limit the area to non-residential land uses.

Area B

The preferred alternative for groundwater in Area B is Alternative B-GW3, Protection of the Water Table and Yorktown Aquifers for Beneficial Use Through Extraction and Treatment, Institutional Controls, and Monitoring. Extraction and treatment of both aquifers in Area B is recommended because, in general, the levels of contaminants in Area B groundwater are higher than in Areas A1 and A2. Additionally, although there are no groundwater users downgradient of Area B, extraction and treatment of groundwater in both aquifers is recommended in this area to contain the contaminant plume. Groundwater in the upper Yorktown Aquifer would be extracted through a series of pumping wells (approximately 65 feet deep). Groundwater in the water table aquifer would be extracted through a series of shallow pumping wells (approximately 25 feet deep). Extracted groundwater from both aquifers would be pumped to an on-site treatment system. The treatment system, which would include metals removal via clarification/filtration, and removal of organics via air stripping and carbon adsorption, would be sized to accommodate groundwater flows from Areas A1, A2, and B.

A groundwater monitoring program would be implemented to assess trends in groundwater quality over time and to evaluate the effectiveness of the groundwater extraction and treatment system. Additionally, existing fencing in Area B would be maintained, and deed restrictions would be implemented to limit the area to non-residential land uses.

This combination of response actions is expected to provide effective source control at the site, to substantially reduce the potential for migration of contamination, and to significantly reduce potential human health and environmental risks associated with the site. For a more detailed analysis and evaluation of remedial alternatives, the reader is referred to the Camp Allen Landfill Site Final Feasibility Study.

SECTION 9.0 TABLES

TABLE 9-1

SOIL CLEANUP GOALS
CAMP ALLEN LANDFILL SITE, NORFOLK, VIRGINIA

CONTAMINANTS OF CONCERN	GROUNDWATER GOAL* (ppm)	SOIL CLEANUP GOAL (ppm)
1,2-Dichloroethane	0.005	0.05
1,2-Dichloroethene (cis)	0.070	3.1
1,1,1-Trichloroethane	0.200	21.3
Benzene	0.005	0.2
Ethylbenzene(1)	0.700	500
Tetrachloroethene	0.005	1.4
Toluene	1.000	220.7
Trichloroethene	0.005	0.5
Vinyl Chloride	0.002	0.01
Xylenes(1)	10.00	7,000

* Soil cleanup goals are derived from groundwater goals, which are based on Federal Safe Drinking Water Act Maximum Contaminant Levels (MCLs), USEPA, May 1993.

(1) Monte Carlo analyses not performed for these compounds.

TABLE 9-2

GROUNDWATER CLEANUP GOALS ($\mu g/L$)
CAMP ALLEN LANDFILL SITE, NORFOLK, VIRGINIA

Contaminants of Concern	Yorktown Aquifer[1] Cleanup Goals (µg/L)	Water Table Aquifer[2] Cleanup Goals (µg/L)	Federal AWQC[4]		Maximum Concentration Detected in Groundwater[5]
			Freshwater Chronic	Marine Chronic	
1,2-Dichloroethane	5	190	20,000	--	600
1,2-Dichloroethene (cis)	70	15,000	--	--	3,807
1,1,1-Trichloroethane	200	13,500	--	--	ND
Benzene	5	600	--	700	600
Ethylbenzene	700	150,000	--	--	ND
Tetrachloroethene	5	340	840	450	354
Toluene	1,000	301,000	--	5,000	567
Trichloroethene	5	1,600	21,900	--	699
Vinyl Chloride	2	9	--	--	ND
Xylenes	10,000	3,000,000	--	--	672

(1) Based on federal Safe Drinking Water Act Maximum Contaminant Levels (MCLs), USEPA, May 1994.

(2) Based on incidental ingestion under a nonpotable use scenario and an incremental cancer risk of 1×10^{-6} and a hazard quotient (HQ) of 1.0 for children.

(3) Cleanup goals are based on contaminants found in soil and groundwater during the pre-design investigation.

(4) Ambient water quality criteria (AWQC) are included to present a comparison between groundwater cleanup goals and surface water quality criteria. AWQC standards are based on Federal Water Quality Criteria (USEPA Water Quality Criteria, May 1, 1991).

(5) Maximum concentration detected in groundwater during the pre-design investigation.

ND = Not detected

-- = Criteria not available

10.0 STATUTORY DETERMINATIONS

A selected remedy must satisfy the statutory requirements of CERCLA Section 121, which include:

- Protection of human health and the environment
- Compliance with ARARs (or justification of a waiver)
- Cost-effectiveness
- Utilization of permanent solutions and alternative treatment or resource recovery technologies to the maximum extent practicable.
- Preference for treatment that reduces toxicity, mobility, or volume as a principal element, or explanation as to why this preference is not satisfied.

The evaluation of how the selected remedy for the Camp Allen Landfill Site satisfies these requirements is presented below.

10.1 Protection of Human Health and the Environment

The selected remedy provides protection to human health and the environment through extraction and treatment of groundwater in Areas A and B, in situ treatment of soil in Area A (Area B soil has been excavated and disposed off site through a removal action), monitoring of groundwater and surface water/sediments, and institutional controls, as described below.

Groundwater is not used for any purpose at the site or in the immediate vicinity of the site. Public water in the area is provided by the City of Norfolk. Nonetheless, the Yorktown Aquifer is the primary source of potable water in the region. The selected remedy provides for extraction and treatment of groundwater in the Yorktown Aquifer in Areas A1 and B. The extraction and treatment system is designed to prevent migration of contaminated groundwater off site. The selected remedy does not provide for extraction and treatment of the Yorktown Aquifer in Area A2, since there are no downgradient receptors and the plume is not expected to migrate off Navy property in this area. In Area A2 and B, the water table aquifer will also be extracted and treated. In Area A1, the water table aquifer is not amenable to extraction due to its low hydraulic conductivity. Therefore, the water table aquifer in Area A1 will be addressed by the dual phase vacuum extraction (DPVE) and treatment, which is proposed for Area A1 soils.

In Areas A1 and B, the selected remedy will prevent exposure (i.e., ingestion, inhalation, dermal contact) to groundwater exceeding drinking water standards (i.e., MCLs) in the Yorktown Aquifer through extraction and treatment, which will prevent further migration of contaminated groundwater and gradually reduce contaminant levels. In Area A2, this exposure pathway will be controlled through use of institutional controls, which will prevent consumption of contaminated groundwater in this area. If groundwater is eventually restored to the MCLs, then site risks associated with potable use of groundwater will be reduced to within the 1×10^{-4} to 1×10^{-6} range for the carcinogenic contaminants, and hazard indices will be reduced to less than one for noncarcinogenic contaminants. Implementation of the selected remedy for the Yorktown Aquifer should pose no unacceptable short-term risks to human health or the environment nor cause any cross-media adverse impacts.

In Areas A1, A2, and B, the selected remedy will prevent exposure (i.e., ingestion, inhalation, dermal contact) to groundwater exceeding nonpotable-use cleanup goals in the water table aquifer through extraction and treatment, which will prevent further migration of contaminated groundwater and gradually reduce contaminant levels. Exposure pathways will also be controlled through use of institutional controls to prevent consumption of contaminated groundwater. If groundwater is eventually restored to the cleanup goals, then site risks associated with nonpotable use of groundwater will be reduced to within the 1×10^{-4} to 1×10^{-6} range for the carcinogenic contaminants, and hazard indices will be reduced to less than one for noncarcinogenic contaminants. Implementation of the selected remedy for the water table aquifer should pose no unacceptable short-term risks to human health or the environment nor cause any cross-media adverse impacts.

The contaminated soil and shallow groundwater in Area A1 will be treated in situ via a dual phase vacuum extraction (DPVE) system, which removes contaminated soil gas and shallow groundwater for subsequent treatment. Treatment of the Area A1 soil will protect the underlying groundwater by reducing contamination and subsequent leaching of contaminants into the groundwater. Thus, the selected soil remedy will help to achieve the groundwater restoration objectives and associated risk reductions. Risks associated with exposure to potential contaminants within the landfills through direct contact (e.g., ingestion, dermal contact) will be mitigated through use of institutional controls to prevent residential use of the area. Implementation of the selected remedy for the soils should pose no unacceptable short-term risks to human health or the environment nor cause any adverse cross-media impacts.

The selected remedy includes monitoring of groundwater and surface water/sediments. A groundwater monitoring program will be implemented to assess trends in groundwater quality over time and to evaluate the effectiveness of the groundwater extraction and treatment system. A surface water/sediment monitoring program will be implemented to track trends in the surface water/sediment quality at the site. Source controls that are being implemented at Area A and B are expected to improve the quality of surface water and sediments at the site over time.

The institutional controls to be implemented at the site would include aquifer use restrictions and deed restrictions limiting the area to non-residential land use.

10.2 Compliance With Applicable or Relevant and Appropriate Requirements

The selected remedy will comply with applicable or relevant and appropriate requirements (ARARs). No ARAR waivers are anticipated. Some of the key ARARs are discussed below. Compliance with the remaining state and federal ARARs is outlined in Table 10-1. Federal and state TBC requirements are provided in Table 10-2.

Specifically, groundwater cleanup goals for the Yorktown Aquifer comply with Safe Drinking Water Act maximum contaminant levels (Federal MCLS). Groundwater cleanup goals for the water table aquifer are risk-based levels for nonpotable use. Groundwater recovered by the extraction system would be treated at the on-site groundwater treatment plant and would be discharged in accordance with the Virginia Pollution Discharge Elimination System (VPDES) (VR 680-14-01) Regulations and the Virginia Water Protection Permit Regulations (VR 680-15-01). Under these regulations, effluent limits are established based on the Virginia Water Quality Standards (VR 680-21-00) for surface water. At the Camp Allen Landfill Site, the only contaminant in groundwater that exceeds the appropriate Virginia surface water standard is trichloroethene (TCE). Therefore, the DoN has proposed a discharge limit to the VADEQ for only this contaminant. The proposed discharge limit for TCE is 807 μg/L, as shown in Table 10-1.

For the DPVE system in Area A1, air emissions would be treated and/or monitored to comply with the Virginia Air Emissions Standards as set forth in Virginia Regulations for the Control and Abatement of Air Pollution (VR 120-01). Recovered solvents generated by the extraction system would be disposed or treated in accordance with applicable RCRA regulations. Air emission calculations provided in Appendix E of the Final Feasibility Study indicate that air stripper emissions should qualify for a permit exemption determination under the Virginia Regulations for the Control and Abatement of Air Pollution.

In addition, the selected remedy will comply with the appropriate portions of RCRA, Virginia Solid and Hazardous Waste Management Regulations, the Department of Transportation (DOT) Rules for Hazardous Materials Transport and the Protection of Wetlands Order.

10.3 Cost-Effectiveness

The selected remedy provides overall cost-effectiveness (benefits proportional to cost). With respect to groundwater, the selected remedy is the most cost-effective alternative that complies with ARARs and protects the Yorktown Aquifer and water table aquifer for their respective potential beneficial uses. With respect to Area A1 soil, in situ treatment is the most cost-effective of the treatment alternatives. Since Area A is a relatively large landfill (45 acres), treatment that would require excavation or removal of the landfill would not be cost-effective. With respect to surface water/sediment, monitoring is the most cost-effective remedy, since these media are expected to improve in quality over time due to the source control actions that are being implemented at the site.

10.4 Utilization of Permanent Solutions and Alternative Treatment Technologies

The selected remedy utilizes permanent solutions and treatment technologies to the maximum extent practicable. The selected remedy utilizes groundwater extraction and treatment technologies in all areas of the site except for the Yorktown Aquifer in Area A2. Groundwater extraction and treatment in this area was determined not to be practicable at this time because the extent of contamination is limited, and contaminated groundwater does not appear to be migrating off Navy property. However, the selected remedy includes construction of a groundwater treatment system with sufficient capacity to treat additional groundwater from Area A2 if necessary in the future.

The selected remedy provides the best balance of tradeoffs among the alternatives with respect to the evaluation criteria, especially the five balancing criteria. The criteria that were most critical in the selection decision are overall protection, long-term effectiveness and permanence, and reduction in toxicity, mobility, and volume of contamination through treatment. These three criteria all relate the ability of the alternatives to attain of the remedial action objectives, which include preventing exposure to contaminated groundwater, preventing further migration of contaminated groundwater, and restoring groundwater to the cleanup levels.

With respect to the key tradeoffs that were involved in the remedy selection process, cost and implementability factors were balanced against overall protection, long-term effectiveness, and reduction in toxicity, mobility, and volume of contamination. Except for Area A2, the selected remedy for groundwater is the most costly and most difficult alternative to implement; however, it will provide the highest degree of protection and long-term risk reduction. In contrast, for the Yorktown Aquifer in Area A2, institutional controls and monitoring can be implemented at a much lower cost than groundwater extraction and treatment; however, these actions may not achieve as high a level of protection as groundwater treatment. With respect to the soil alternatives, the selected remedy will not achieve the same degree of contaminant removal as would the thermal treatment or off-site disposal alternatives; however, it can be implemented at a significantly lower cost and will achieve the main objective of preventing migration of contaminants from soil to groundwater.

The State and community acceptance criteria were factored into the decision making process as part of the public comment period for the PRAP. Several comments on the PRAP were received from the Commonwealth of Virginia, which are addressed in the Responsiveness Summary. However, no State comments were received that affected the selected remedy outlined in the PRAP. In addition, one comment was received from a community representative.

10.5 Preference for Treatment as a Principal Element

Treatment, the selected remedy, addresses the principal threats posed by both groundwater and soil contamination. With respect to groundwater, the selected remedy utilizes groundwater treatment technologies including metals pretreatment, air stripping, and carbon adsorption. With respect to Area A1 soil, the selected remedy utilizes dual phase vapor extraction with treatment of the recovered groundwater (treatment described above) and treatment of the soil gas (if required) via vapor phase carbon adsorption.

SECTION 10.0 TABLES

TABLE 10-1

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs)
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Citation	Requirement	ARAR Determination	Comments
FEDERAL/CONTAMINANT-SPECIFIC			
Safe Drinking Water Act (42 USC 300(f)) a. Maximum Contaminant Levels (MCLs) 40 CFR 141.11-141.16 b. Maximum Contaminant Level Goals (MCLGs) 40 CFR 141.50-141.51	Standards for protection of drinking water sources serving at least 25 persons. MCLs consider health factors, as well as economic and technical feasibility of removing a contaminant; MCLGs do not consider the technical feasibility of contaminant removal. For a given contaminant, the more stringent of MCLs or MCLGs is applicable unless the MCLG is zero, in which case the MCL applies.	Relevant and appropriate in developing cleanup goals for contaminated groundwater and surface water that may potentially be used as a potable water supply.	MCLs were used in developing cleanup goals for the Yorktown Aquifer (see Table 9-2 in Section 9.0).
FEDERAL/LOCATION-SPECIFIC			
Executive Order 11988 (related to Floodplain Management)	Regulates activities located in a floodplain. Federal activities in floodplains must reduce the risk of flood loss, minimize the impact of floods on human safety, health and welfare, and preserve the natural and beneficial values served by floodplains.	Applicable for remedial actions involving activities with a floodplain. Site is located within a 100-year floodplain.	Activities during construction will comply with requirements.
FEDERAL/ACTION-SPECIFIC			
DOT Rules for Hazardous Materials Transport (49 CFR Parts 107 and 171.1-500)	Regulates the transport of hazardous waste materials including packaging, shipping, and placarding.	Applicable for any action requiring off-site transportation of hazardous materials.	Remedial actions may include off-site treatment and disposal (e.g., off-site regeneration of activated carbon).
Resource Conservation and Recovery Act (RCRA) Subtitle C	Regulates the treatment, storage, and disposal of hazardous waste.	Applicable to remedial actions involving treatment, storage, or disposal of hazardous waste.	Remediation may involve treatment, storage, or disposal of hazardous waste.
Identification and Listing of Hazardous Waste (40 CFR Part 261)	Regulations concerning determination of whether or not a waste is hazardous based on characteristics or listing.	Applicable in determining waste classification.	Some site contaminants are considered listed wastes.
Treatment, Storage, and Disposal (TSD) of Hazardous Waste (40 CFR Parts 262-265, 266)	Regulates the treatment, storage, and disposal of hazardous waste.	Applicable in the event that wastes on site are classified as hazardous.	TSD activities related to hazardous waste will comply with regulations.
Manifest Systems, Recordkeeping, and Reporting (40 CFR Part 264, Subpart E)	Regulates manifest systems related to hazardous waste treatment, storage, and disposal.	Applicable to remedial actions where hazardous waste is generated or transported.	Remedial actions may include off-site disposal or treatment.
Releases from Solid Waste Management Unites (40 CFR Part 264, Subpart F)	Regulates releases from solid waste management units.	All solid waste management units on site shall comply with requirements.	Groundwater protection standards apply to solid waste management units.

TABLE 10-1 (Continued)

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs)
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Citation	Requirement	ARAR Determination	Comments
Use and Management of Containers (40 CFR Part 264, Subpart I)	Regulates use and management of containers being stored at all hazardous waste facilities.	Applicable to containers stored on site.	Remedial actions may generate containerized waste. Investigation-derived waste (IDW) is containerized.
Resource Conservation and Recovery Act (RCRA) Subtitle D	Regulates the treatment, storage, and disposal of solid waste.	Applicable to remedial actions involving treatment, storage, or disposal of materials classified as solid waste.	Remediation may include treatment, storage, or disposal of solid waste.
STATE/CONTAMINANT-SPECIFIC			
Virginia Water Quality Standards (VR 680-21-00)	Surface water quality standards based on water use and criteria class of surface water.	Applicable to remedial actions requiring discharge to surface water.	Will be used to determine the discharge limit from the treatment facility. The Navy has proposed a discharge limit of 807 µg/L for trichloroethene to the VADEQ, based on the Virginia Water Quality Standard.
Virginia Emission Standards for Toxic Pollutants (VR 120-01)	Establishes acceptable limits for toxic pollutants by applying a 1/40 correction factor to the occupational standard Threshold Limit Value-Ceiling (TLV-Ceiling). Also provides rules for making an exemption determination based on quantities of pollutants emitted.	These standards are applicable requirements for remedial actions requiring discharge to the atmosphere. Air calculations are provided in Appendix E of the Final Feasibility Study that demonstrate that air stripper emissions should qualify for an exemption from the air emission standards.	To be used during the remedial action to determine whether air emissions from the treatment facility will exceed air emission standards.
Virginia Pollution Discharge Elimination System (VPDES) (VR 680-14-01) Regulation and Virginia Water Protection Permit Regulations (VR 680-15-01)	Regulated point-source discharges through the VPDES permitting program. Permit requirements include compliance with corresponding water quality standards, establishment of a discharge monitoring system, and completion of regular discharge monitoring records.	Applicable to discharge of treated water to surface water.	Substantive requirements of VPDES permit will be used to determine the discharge limits for the discharge of the treated water to surface water on site. Monitoring requirements are associated with VPDES regulations. The VADEQ is currently reviewing the discharge limits proposed by the Navy.
STATE/ACTION-SPECIFIC			
Virginia Solid Waste Management Regulations (VR 672-20-10)	Regulates the disposal of solid wastes.	Applicable for solid (nonhazardous) waste.	Remedial actions could include off-site disposal of nonhazardous waste.
Virginia Hazardous Waste Management Regulations (VR 672-10-1, Parts VI and VII) Regulations Governing the Transportation of Hazardous Materials (VR 672-30-1)	Regulates the transport of hazardous waste materials including packaging, shipping, and placarding.	Applicable for any action requiring off-site transportation of hazardous materials.	Remedial actions may include off-site treatment and disposal (e.g., off-site regeneration of activated carbon).

TABLE 10-1 (Continued)

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs)
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Citation	Requirement	ARAR Determination	Comments
STATE/ACTION-SPECIFIC			
Virginia Hazardous Waste Management Regulations (VR 672-10-1)	Regulates the treatment, storage, and disposal of hazardous waste.	Applicable to remedial actions involving treatment, storage, or disposal of hazardous waste.	Remediation may include treatment, storage, or disposal of hazardous waste.
Identification and Listing of Hazardous Waste (VR 672-10-1, Part III)	Regulations concerning determination of whether or not a waste is hazardous based on characteristics or listing.	Applicable in determining waste classification.	Some site contaminants are considered listed wastes.
Manifest Systems, Recordkeeping, and Reporting (VR 672-10-1, Part IX, Section 9.4)	Regulates manifest systems related to hazardous waste treatment, storage, and disposal.	Applicable to remedial actions where hazardous waste is generated or transported.	Remedial actions may include off-site disposal or treatment.
Use and Management of Containers (VR 672-10, Part X, Section 9.8)	Regulates use and management of containers being stored at all hazardous waste facilities.	Applicable to containers stored on site.	Remedial actions may generate containerized waste. Investigation-derived waste (IDW) is containerized.
Landfills - Post Closure Requirements (VR 672-10, Part IX, Section 9.13)	Regulates post-closure requirements for hazardous waste landfills.	Relevant and appropriate for post-closure groundwater monitoring.	Remedial activities will incorporate post-closure groundwater monitoring.
Virginia Stormwater Management Regulations (VR 215-02-00) and Virginia Erosion and Sediment Control Regulations (VR 625-02-00)	Regulates stormwater management and erosion/ sedimentation control practices that must be followed during land disturbing activities.	Applicable for remedial actions involving land disturbing activities.	Activities during construction will comply with the Virginia Storm Water Management Program. A sediment and erosion control plan will be submitted to LANTDIV for approval.
Virginia Wetlands Regulations (VR 450-01-0051)	Regulates activities that impact tidal wetlands.	Relevant and appropriate to activities that could impact site wetlands.	VADEQ has been notified that remedial activities could impact adjacent wetlands. No comments from VADEQ have been received.
Chesapeake Bay Preservation Area Designation and Management Regulations (VR 173-02-01)	Sets limitations in certain tidal and wetland areas for land-disturbing activities, removal of vegetation, use of impervious cover, E&S control, stormwater management, etc.	Potentially relevant and appropriate if site is within jurisdiction.	If required, plans will be submitted to the appropriate agency for approval.

TABLE 10-2

TO BE CONSIDERED (TBC) REQUIREMENTS
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Citation	Requirement	TBC Determination	Comments
FEDERAL/CONTAMINANT-SPECIFIC			
Reference Doses (RfDs), EPA Office of Research and Development	Presents non-enforceable toxicity data for specific chemicals for use in public health assessments to characterize risks due to exposure to contaminants.	To be considered (TBC) requirement in the public health assessment.	Will be used in evaluating human health risks at the site.
Carcinogenic Potency Factors, EPA Environmental Criteria and Assessment Office; EPA Carcinogen Assessment Group	Presents non-enforceable toxicity data for specific chemicals for use in public health assessments to compute the individual incremental cancer risk resulting from exposure to carcinogens.	TBC requirement in the public health assessment.	Will be used in evaluating human health risks at the site.
Health Advisories, EPA Office of Drinking Water	Non-enforceable guidelines for chemicals that may intermittently be encountered in public water supply systems. Available for short- or long-term exposure for a child and/or adult.	TBC requirement in the public health assessment.	Will be used in evaluating human health risks at the site.
FEDERAL/LOCATION-SPECIFIC			
RCRA Subtitle C Landfills (40 CFR Part 264, Subpart N)	Regulates owners and operators of facilities that dispose hazardous wastes in landfills.	TBC to evaluate compliance of off-site landfills.	TBC for remedial actions that involve off-site landfill of hazardous waste (sludge or IDW).
Groundwater Protection Strategy	EPA policy to protect groundwater for its highest present or potential beneficial use. The strategy designates three categories of groundwater: Class 1 - Special Ground Waters Class 2 - Current and Potential Sources of Drinking Water and Waters Having Other Beneficial Uses Class 3 - Groundwater Not a Potential Source of Drinking Water and of Limited Beneficial Use	TBC requirement.	Groundwater in the Yorktown Aquifer is considered a Class 2 given its historical, current, and expected future use. Groundwater in the surficial (water table) aquifer is considered a Class 3.

TABLE 10-2 (Continued)

TO BE CONSIDERED (TBC) REQUIREMENTS
CAMP ALLEN LANDFILL, NORFOLK, VIRGINIA

Citation	Requirement	TBC Determination	Comments
FEDERAL/ACTION-SPECIFIC			
Control of Air Emissions from Superfund Air Strippers at Superfund Ground Water Sites (OSWER Directive 9355.0-28)	Guidance that establishes criteria as to whether air emission controls are necessary for air strippers. A maximum 3 lbs/hr or 15 lbs/day or 10 tons/yr of VOC emissions is allowable; air pollution controls are recommended for any emissions in excess of these quantities.	TBC requirement.	TBC as remedial action includes air stripping.
STATE/LOCATION-SPECIFIC			
RCRA Subtitle C Landfills (VR 672-10, Part X, Section 10.13)	Regulates owners and operators of facilities that dispose hazardous wastes in landfills.	TBC to evaluate compliance of off-site landfills.	TBC for remedial actions that involve off-site landfill of hazardous waste (sludge or IDW).

11.0 RESPONSIVE SUMMARY

11.1 Background on Community Involvement

A record review of the Naval Base Norfolk files indicates an active community involvement program. The primary communities for the Camp Allen Landfill investigation include the adjacent Glenwood Park neighborhood, the Camp Allen Elementary School, and the Navy housing area of Capehart.

Community relations activities to date for the Camp Allen Landfill site are summarized below:

- Conducted community relations interviews with base personnel, local officials, residents, and civic and environmental groups. A total of 15 persons were interviewed.

- Prepared a Community Relations Plan, dated May 27, 1993. Plan was based on community interviews and historic community involvement.

- Established three local information repositories.

- Established the Administrative Record for all of the sites under investigation at the base.

- Sampled the Glenwood Park residential wells, at the request of the residents. All Glenwood Park residents are on public water, which is supplied by the City of Norfolk; however, some have domestic wells which they use for garden/lawn watering. Analytical results of the water testing were provided to the residents.

- Canvassed the primary communities and distributed numerous Fact Sheets during the investigation.

- Briefed neighbors on monitoring well installation in Glenwood Park.

- Participated and attended many Glenwood Park Civic League meetings.

- Provided frequent briefings, to the Camp Allen Elementary School, especially during the field investigation stage.

- Released the Final PRAP for public review and comment in the information repositories on March 6, 1995.

- Released public notice announcing public comment period and document availability of the PRAP on March 6, 1995.

- Held a Restoration Advisory Board (formerly Technical Review Committee) meeting, in which the public was invited to attend, on March 22, 1995 to review the PRAP and solicit comments.

11.2 Summary of Public Comments

This section addresses written comments received during the public comment period and the public comments received from those attending the public meeting. Please note that comments were received from the Virginia Department of Environmental Quality (VADEQ). In addition, one question was posed from a Restoration Advisory Board member during the March 22, 1995 meeting. Comments and responses are presented below.

11.2.1 Response to VADEQ Comments on Final PRAP

1. *Page 2-5, Section 2.3.2: This section refers to surface soil as nominally impacted. Please clarify this statement as there were several contaminants that exceed risk-based concentrations in surface soil. Table 2-1 uses a similar description.*

   RESPONSE: As described in the Final RI Report, dated July 1994, no contaminants of potential concern were found in surface soils. Also, the Revised Final Risk Assessment, dated February 24, 1995, indicates that there are no unacceptable risks associated with surface soils. Please note that the Area A landfill is covered with a cover soil material and is vegetated with a heavy grass cover that is regularly maintained to prevent erosion. Therefore, the waste material is covered and is not exposed at the surface of the landfill.

2. *Page 2-7, Section 2.4: This section refers to the Remedial Action Closeout Report for the Area B Landfill removal action. Note that this report was only recently received by this office and will be reviewed to verify that remedial actions are not required for Area B soils.*

RESPONSE: Comment noted.

3. *Table 3-1: Note that the ARARs comments submitted by the state (February 3, 1995 letter from Erica Dameron to Nina Johnson) have not been incorporated into the final document. The comments are as follow:*

a) The identification of VPDES as an ARAR may require some revision to indicate that this is a permitted activity. Also, the comments for the VPDES regulations should indicate that there are monitoring requirements associated with the discharge regulations.

b) The citation to the "Virginia Hazardous Waste Regulations", as used to identify requirements for the transport of hazardous materials, should be changed to "Virginia Hazardous Waste Management Regulations (VR 672-10-1, Parts VI and VII) and Regulations Governing the Transportation of Hazardous Materials (VR 672-30-1)".

c) Some specific sections of Part X of the Virginia Hazardous Waste Management Regulations (VHWMR) are identified as subparts under the general citation. Part IX of VHWMR should be referenced in place of Part X because Part IX is applicable to unpermitted units. Also, VHWMR Section 9.13, Landfills, should be included in this section of the table.

Note that VHWMR Section 9.13.D addresses the requirements for landfill closure and post-closure care. The questions raised by EPA in the third paragraph of comment #12 (letter from Stacie Morekas Driscoll to Dave Forsythe dated February 23, 1995) regarding state *closure requirements should be addressed in relation to this section. Also note that the date of closure, as stated in LANTDIV's response to EPA comments (letter to Stacie Driscoll from Nina Johnson dated March 20, 1995), does not affect the determination of whether this section is relevant and appropriate to the proposed remedial action.*

It should be noted that 9.13.D. does require a final cover. However, if it can be shown that the proposed remedial action would be as protective as the cover described in this section, then the requirement for the cover may not necessarily be considered relevant and appropriate. In addition, it must be shown that the landfill would not be an eyesore if it were not covered in order to comply with Part IV of the Virginia Solid Waste Management Regulations.

All groundwater monitoring requirements must be met. If groundwater monitoring indicates that cleanup goals cannot be met, the decision not to cover the landfill as part of the final remedy will have to be reevaluated.

RESPONSE: The ARAR tables presented in the Decision Document have been revised in accordance with VADEQ comments.

As previously stated, the Area A Landfill has a vegetated soil cover that is well-maintained. The landfill area certainly would not be described as an eyesore - it is a relatively flat, open area that is covered with grass which is mowed on a regular basis. The Navy Brig facility and a heliport are located on top of the Area A Landfill.

There is no data available at this time to evaluate the permeability of the existing landfill cover. The absence of a confining layer, combined with a high water table, would limit the effectiveness of a cap. Furthermore, placement of an impermeable cover over the landfill may actually be counterproductive in light of the selected remedial action (groundwater extraction and treatment). The current cover material allows some infiltration, which flushes contaminants within the landfill into the water table aquifer where they can be extracted and treated.

Virginia post-closure groundwater monitoring requirements will be met by the long-term monitoring program to be implemented under the selected remedy.

4. *Section 4.1: The summary of site risks for each medium should also mention the contaminants that are driving any unacceptable risks.*

RESPONSE: The chemicals contributing most predominantly to site risks have been added to the Decision Document and are listed below, by environmental medium:

AREA A

Shallow and Deep Groundwater
- 1,2-Dichloroethene
- Vinyl chloride
- Trichloroethene

Soils
- Arsenic
- Cadmium

Surface Water
- Aroclor-1254

Sediment
- Arsenic
- Aroclor-1254
- Aroclor-1260

AREA B

Shallow and Deep Groundwater
- 1,2-Dichloroethene
- Benzene
- Vinyl chloride
- Trichloroethene
- Arsenic

Sediments
- Arsenic
- Cadmium

The contaminants of concern are indicated in Section 2.5 of the PRAP. The above-listed risk-drivers will be added to the Decision Document.

5. *Page 4-7, Section 4.3.1: This section states that achievement of the remediation goals for soil will be based on monitoring of contaminant levels in groundwater. Does this imply that there will not be any confirmation sampling in soil during and after the remedial action? Confirmatory soil sampling should be performed to insure that there is no unacceptable risk due to soil contact, particularly if there will not be a final cover on the landfill.*

RESPONSE: There will be no confirmatory sampling of soils (i.e., landfill materials) following remediation. As stated in the PRAP, achievement of soil remediation goals will be based on monitoring of contaminant levels in groundwater. Since the area is a landfill, the primary goal of the remediation is protection of the underlying groundwater rather than soil cleanup (soil cleanup levels were based on groundwater protection rather than direct contact risk). This concept was clearly stated in the Feasibility Study, which was reviewed and approved by VADEQ. The landfill cover, which provides a barrier to direct contact with landfill waste material, has been described in previous responses.

6. *Page 4-7, Section 4.3.2 states that the cleanup goals for each aquifer have been developed based on the potential beneficial use. Therefore, the cleanup goals for the shallow aquifer are based on nonpotable use. However, in Appendix B of the Final Feasibility Study (FS) it appears that soil cleanup levels are being set to achieve Maximum Contaminant Levels (MCLs) in the shallow aquifer. Please clarify this apparent discrepancy.*

RESPONSE: Soil cleanup goals were based on MCLs as a conservative measure since they were derived from various assumptions associated with the Summers leaching model. This point has been clarified in the Decision Document.

7. *Although it has been stated that the shallow aquifer is not currently used as a potable source, there is no statement confirming that the shallow aquifer cannot be used as a potable source in the future. If the cleanup levels for the shallow aquifer are based on nonpotable use, the document should include a definitive statement that the water will not be used as a potable source. (As discussed at the RAB meeting on March 22, 1995, the City of Norfolk does not allow potable use of the upper aquifer. A citation of this city ordinance would help to justify the use of nonpotable cleanup goals. If there are physical properties of the aquifer that make it unacceptable for drinking, these should be mentioned as well.)*

RESPONSE: The Decision Document includes a statement indicating that the shallow aquifer cannot be used as a potable water source due to a City of Norfolk ordinance that does not allow potable use of the shallow aquifer. In addition, the shallow aquifer in the vicinity of the site is generally not suitable for potable use due to high concentrations of iron, manganese and suspended solids, as well as low pH (less than 6).

8. *Appendix B of the FS uses Monte Carlo simulation to set soil cleanup levels. However, the model inputs are given as discreet values rather than distributions in Attachment II. Please explain how Monte Carlo simulation was used in setting cleanup levels. Also, results at different percentiles in addition to the expected value should be shown and discussed.*

RESPONSE: Three variable parameters were designated for Monte-Carlo simulations of the Summers model. These variables included depth to the water table, organic carbon fraction and vertical hydraulic conductivity. The uncertainties associated with the value range inputs of these parameters were defined by triangular distributions described by minimum, mean and maximum values.

A detailed distributional analysis, a rather involved statistical process, would be necessary to estimate percentile levels with a higher degree of certainty than those based on input ranges described by triangular distributions. As previously noted, the soil cleanup levels were based on MCLs as a conservative measure to account for uncertainties associated with the modeling effort. Statistical efforts were deemed unnecessary for the purpose of defining cleanup goals in the FS.

9. *The shallow aquifer cleanup levels have been set to achieve a hazard quotient of one for individual contaminants. The cleanup levels should be set to achieve a hazard index of one for multiple contaminants unless it can be shown that the effects of the contaminants would not be additive.*

RESPONSE: Use of a target hazard quotient (THQ) of unity in the Final Risk Assessment Report was approved by both the State and EPA.

10. *Table 6-5: The evaluation of long-term effectiveness and permanence states that risks would exceed acceptable levels if shallow and deep aquifers were used for potable use on-site under alternative A1-GW3. However, if the Yorktown Aquifer is treated to the proposed cleanup levels, potable use would be within acceptable risk levels (except as noted above for HIs). This statement should be clarified. Similar statements are made on Tables 6-6 and 6-7.*

RESPONSE: The Decision Document clarifys that under current conditions, risks exceed acceptable levels for both the shallow and deep aquifers for potable use; however, after remediation, the Yorktown Aquifer would be within the acceptable range.

11. *The Yorktown Aquifer cleanup levels have been set to achieve MCLs for individual contaminants. For the carcinogenic contaminants, the estimated risk at the cleanup levels (rounded to one significant figure) would be 1 x 10^{-4} and would, therefore, be considered acceptable. However, for the noncarcinogenic contaminants, the hazard index at the cleanup levels exceeds unity. As noted above, the cleanup levels should be set to achieve a hazard index of one for multiple contaminants unless it can be shown that the effects of the contaminants would not be additive.*

RESPONSE: See response to Comment 9.

11.2.2 Response to Restoration Advisory Board Member Comment

1. *Mr. Nathaniel Riggins: What was the depth of the shallow wells in Glenwood Park?*

RESPONSE: Fifty-five shallow (non-potable) wells averaging 20 feet in depth were sampled. The Yorktown Aquifer at the site is approximately 40 feet below ground surface.

12.0 REFERENCES

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Risk Assessment Guidance for Superfund Volume I, Human Health Evaluation Manual Supplemental Guidance. "Standard Default Exposure Factors" Interim Final. Office of Solid Waste and Emergency Response. Washington, D. C. March 25, 1991. OSWER Directive 9285.6-03.

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